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A GUIDE

TO

THE STUDY OF INSECTS,

AND A TREATISE ON THOSE

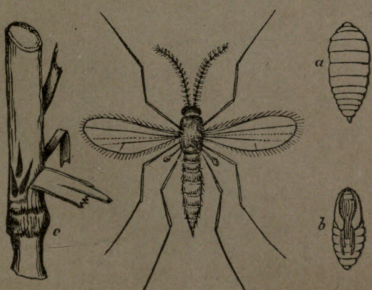
INJURIOUS AND BENEFICIAL TO CROPS.

FOR THE USE OF COLLEGES, FARM-SCHOOLS, AND AGRICULTURISTS.

BY

A. S. PACKARD, Jr., M. D.

WITH UPWARDS OF FIVE HUNDRED ENGRAVINGS.



THE HESSIAN FLY AND ITS YOUNG.

SALEM:
PRESS OF THE ESSEX INSTITUTE.
1868.

GUIDE TO THE STUDY OF INSECTS.

THE CLASS OF INSECTS.

THAT branch of the Animal Kingdom known as the ARTICULATA, includes all animals having the body composed of rings or segments, like short cylinders, which are placed successively one behind the other. Cuvier selected this term because he saw that the plan of their entire organization, the essential features which separate them from all other animals, lay in the idea of articulation, the apparent joining together of distinct segments along the line of the body. If we observe carefully the body of a Worm, we shall see that it consists of a long cylindrical sac, which at regular intervals is folded in upon itself, thus giving a ringed (annulated, or articulated) appearance to the body. In Crustaceans (crabs, lobsters, etc.) and in Insects, from the deposition of a peculiar chemical substance called *chitine*, the walls of the body become so hardened, that when the animal is dead and dry, it readily breaks into numerous very perfect rings.

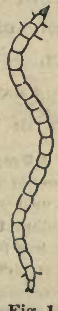


Fig. 1.

Though this branch contains a far greater number of species than any other of the animal kingdom, its myriad forms can all be reduced to a simple, ideal, typical figure; that of a long slender cylinder divided into numerous segments, as in Fig. 1, representing the larva of a Fly. It is by the unequal development and the various modes of grouping them, as well as the differences in the number of the rings themselves, and also in the changes of form of their appendages, *i.e.* the feet, jaws, antennæ, and wings, that the various forms of Articulates are produced.

FIG. 1. Worm-like larva of a Fly, *Scenopinus.*—*Original.*

Articulated animals are also very distinctly *bilateral*, *i.e.* the body is symmetrically divided into two lateral halves, and not only the trunk but the limbs also show this *bilateral symmetry*. In a less marked degree there is also an *antero-posterior symmetry*, *i.e.* each end of the body is opposed, just as each side of the body is, to the other.* The line separating the two ends is, however, imaginary and vague. The antennæ, on the anterior pole, or head, are represented by the caudal, or anal, stylets (Fig. 2), and the single parts on the median line of the body correspond. Thus the labrum and clypeus are represented by the tergite of the eleventh segment of the abdomen.

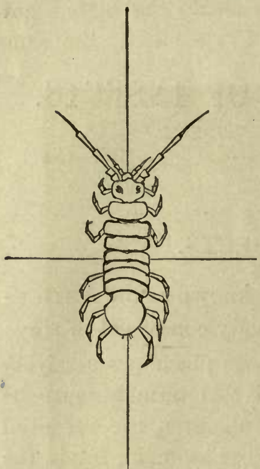


Fig. 2.*

In all Articulates (Fig. 3) the long, tubular, alimentary canal occupies the centre of the body; above it lies the "heart," or dorsal vessel, and below, upon the under side, rests the nervous system. The breathing apparatus, or "lungs," in Worms consists of simple filaments, placed on the front of the head; or of gill-like processes, as in the Crustaceans, which are formed by membranous expansions of the legs; or, as in the Insects (Fig. 4), of delicate tubes (tracheæ), which

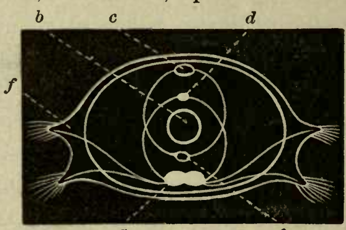


Fig. 3.

* Professor Wyman (On Symmetry and Homology in Limbs, Proceedings of the Boston Society of Natural History, 1867) has shown that antero-posterior symmetry is very marked in Articulates. In the adjoining figure of *Jæra* (Fig. 2) the longitudinal lines illustrate what is meant by bilateral symmetry, and the transverse lines "fore and aft" symmetry. The two antero-posterior halves of the body are very symmetrical in the Crustacean genera *Jæra*, *Oniscus*, *Porcellio*, and other Crustacea, and also among the Myriapods, *Scutigera*, *Polydesmus*, "in which the limbs are repeated oppositely, though with different degrees of inequality, from the centre of the body backwards and forwards." "Leuckart and Van Beneden have shown that Mysis has an ear in the last segment, and Schmidt has described an eye in the same part in a worm, *Amphicora*."—*From Wyman.*

FIG. 3 represents an ideal section of a Worm. *f* indicates the skin, or muscular body-wall, which on each side is produced into one or more fleshy tubercles, usually tipped with bristles or hairs, which serve as organs of locomotion, and

ramify throughout the whole interior of the animal, and connect with breathing pores (stigmata) in the sides of the body. They do not breathe through the mouth as do the higher animals. The tracheæ and blood-vessels follow closely the same

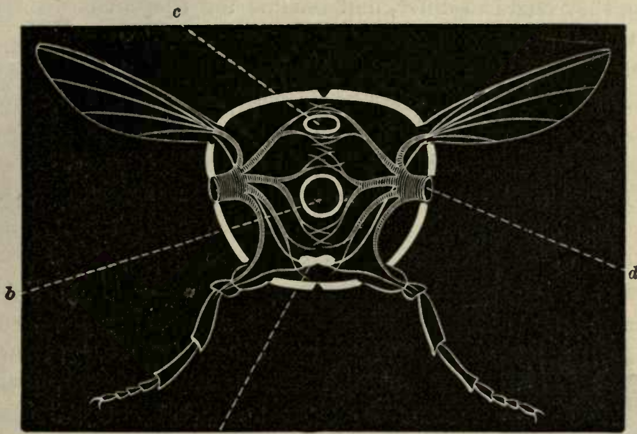


Fig. 4.

course, so that the aëration of the blood goes on, apparently, over the whole interior of the body, not being confined to a single region, as in the lungs of the vertebrate animals.

Thus it is by observing the general form of the body-walls, and the situation of the different anatomical systems, both in relation to themselves and the walls of the body, or crust, which surrounds and protects the more delicate organs within, that we are able to find satisfactory characters for isolating, in our definitions, the articulates from all other animals.

We shall perceive more clearly the differences between the three classes of Articulates, or jointed animals, namely, the WORMS, CRUSTACEANS, and INSECTS, by examining

often as lungs. The nervous cord (*a*) rests on the floor of the cylinder, sending a filament into the oar-like feet (*f*), and also around the intestine or stomach (*b*), to a supplementary cord (*d*), which is situated just over the intestine, and under the heart or dorsal vessel (*c*). The circle *c* and *e* is a diagram of the circulatory system; *c* is the dorsal vessel, or heart, from the side of which, in each ring, a small vessel is sent downwards and around to *e*, the ventral vessel.— *Original.*

FIG. 4. An ideal section of a Bee. Here the crust is dense and thick, to which strong muscles are attached. On the upper side of the ring the wings grow out, while the legs are inserted near the under side. The tracheæ (*d*) enter through the *stigma*, or breathing pore, situated just under the wing, and their branches subdivide and are distributed to the wings, with their five principal veins as indicated

their young stages, from the time of their exclusion from the egg, until they pass into mature life. A more careful study of this period than we are now able to enter upon would show us how much alike the young of all articulates are at first, and how soon they begin to differ, and assume the shape characteristic of their class.

Most Worms, after leaving the egg, are at first like some infusoria, being little sac-like animalcules, often ciliated over nearly the entire surface of the infinitesimal body. Soon this sac-like body grows longer, and contracts at intervals; the intervening parts become unequally enlarged, some segments, or rings, formed by the contraction of the body-walls, greatly exceeding in size those next to them; and it thus assumes the appearance of being more or less equally ringed, as in the young *Terebella* (Fig. 5), where the ciliæ are restricted to a single circle surrounding the body. Gradually (Fig. 6) the ciliæ disappear and regular locomotive organs, consisting of minute paddles, grow out from each side; feelers (antennæ), jaws, and eyes (simple rudimentary eyes) appear on the few front rings of the body, which are grouped by themselves into a sort of head, though it is difficult, in a large proportion of the lower worms, for unskilled observers to distinguish the head from the tail.

Fig. 5.

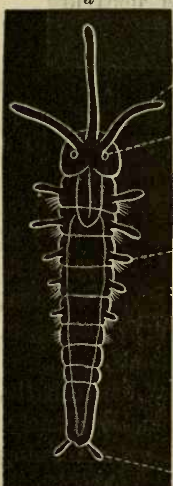


Fig. 6.

Thus we see throughout the growth of the worm, no attempt at subdividing the body into regions, each endowed with its peculiar functions; but only a more perfect system of rings, each relatively very equally developed,

in the figure, also to the dorsal vessel (*c*), the intestine (*b*), and the nervous cord (*a*). The tracheæ and a nervous filament are also sent into the legs and to the wings. The tracheæ are also distributed to the dorsal vessel and intestine by numerous branches which serve to hold them in place. — *Original.*

FIG. 5. Young *Terebella*, soon after leaving the egg. — *From A. Agassiz.*

FIG. 6 represents the embryo of a worm (*Autolytus cornutus*) at a later stage of growth. *a* is the middle tentacle of the head; *e*, one of the posterior tentacles; *b*, the two eye-spots at the base of the hinder pair of feelers; *c* is one of a row of oar-like organs (*cirri*) at the base of which are inserted the locomotive bristles,

but all becoming respectively more complicated. For example, in the Earth-worm (*Lumbricus*), each ring is distinguishable into an upper and under side, and in addition to these a well-marked side-area, to which, as for example in marine worms (e. g. *Nereis*), oar-like organs are attached. In most worms eye-spots appear on the front rings, and slender tentacles grow out, and a pair of nerve-knots (ganglia) are apportioned to each ring.

In the Crustaceans, such as the fresh-water Crawfish (*Astacus*), as shown by the German naturalist Rathke; and also in the earliest stages of the Insect, the body *at once* assumes a worm-like form, thus beginning its embryonic life from the goal reached by the adult worm.

The young of all Crustaceans (Fig. 7) first begin life in the egg as oblong flattened worm-like bodies, each end of the body being alike. The young of the lower Crustaceans, such as the Barnacles, and some marine forms like the *Jæra* and some lowly organized parasitic species inhabiting the gills of fishes, are hatched as microscopic embryos which would readily be mistaken for young mites (*Acarina*). In the higher Crustaceans, such as the fresh-water Crawfish, the young, when hatched, does not greatly differ from the parent, as it has passed through the worm-like stage within the egg.

Fig. 7.

Fig. 7 represents the young of the fresh-water Lobster (Crawfish) before leaving the egg. The body is divided into rings, ending in lobes on the sides, which are the rudiments of the limbs. *b* is the rudiment of the eye-stalk, at the end of which is the eye; *a* is the fore antennæ; *c* is the hind antennæ; *d* is one of the maxilla-feet; *e* is the first pair of true feet destined in the adult to form the large "claw." Thus the eye-stalks, antennæ, claws, and legs are moulded upon a common form, and at first are scarcely distin-

with the cirri serving as swimming and locomotive organs; *d*, the caudal styles, or tail-feelers. In this figure we see how slight are the differences between the feelers of the head, the oar-like swimming organs, and the caudal filaments; we can easily see that they are but modifications of a common form, and all arise from the common limb-bearing region of the body. The alimentary canal, with the proventriculus, or anterior division of the stomach, occupies the middle of the body; while the mouth opens on the under side of the head.—*From A. Agassiz.*

FIG. 7. Embryo of the Crawfish.—*From Rathke.*

guishable from each other. Here we see the embryo divided into a head-thorax and a tail.

It is the same with Insects. Within the egg at the dawn of life they are flattened oblong bodies curved upon the yelk-mass. Before hatching they become more cylindrical, the limbs bud out on the sides of the rings, the head is clearly demarked, and the young caterpillar soon steps forth from the egg-shell ready armed and equipped for its riotous life.

As will be seen in Fig. 8, the legs, jaws, and antennæ are first started as buds from the side of the rings, being simply elongations of the body-wall, which bud out, become larger, and finally jointed, until the buds arising from the thorax or abdomen become legs, those from the base of the head become jaws, while the antennæ and palpi sprout out from the front rings of the head. Thus while the bodies of all articulates are built up from a common embryonic form, their appendages, which are so diverse, when we compare a Lobster's claw with an Insect's antenna, or a Spider's spinneret with the hinder limbs of a Centipede, are yet but modifications of a common form, adapted for the different uses to which they are put by these animals.

Fig. 8.

FIG. 8. A Caddis, or Case-fly (*Mystacides*) in the egg, with part of the yolk (x) not yet inclosed within the body-walls. a, antennæ; between a and b the mandibles; b, maxilla; c, labium; d, the separate eye-spots (ocelli), which afterwards increase greatly in number and unite to form the compound eye. The "neck" or junction of the head with the thorax is seen at the front part of the yolk-mass; e, the three pairs of legs, which are folded once on themselves; f, the pair of anal legs attached to the tenth ring of the abdomen, as seen in caterpillars, which form long antenna-like filaments in the Cockroach and May-fly, etc. The rings of the body are but partially formed; they are cylindrical, giving the body a worm-like form. Here, as in the other two figures, though not so distinctly seen, the antennæ, jaws, and last pair of abdominal legs are modifications of but a single form, and grow out from the side of the body. The head-appendages are directed forwards, as they are to be adapted for sensory and feeding purposes; the legs are directed downwards, since they are to support the insect while walking. It appears that the two ends of the body are perfected before the middle, and the under side before the upper, as we see the yolk-mass is not yet inclosed and the rings not yet formed above. Thus all articulates differ from all vertebrates in having the yolk-mass situated on the back, instead of on the belly, as in the chick, dog, or human embryo.—*From Zaddach.*

The Worm is long and slender, composed of an irregular number of rings, all of very even size. Thus, while the *size* of the rings is fixed, their *number* is indeterminate, varying from twenty to two hundred or more. The outline of the body is a *single* cylindrical figure. The organs of locomotion are fleshy filaments and hairs (Fig. 3, *f*) appended to the sides.

In one of the low intestinal worms, the Tape-worm (*Tœnia*), each ring, behind the head and "neck," is provided with organs of reproduction, so that when the body becomes broken up into its constituent elements, or rings (as often occurs naturally in these low forms for the more ready propagation of the species, since the young are exposed to many dangers while living in the intestines of animals), they become living independent beings which "move freely and somewhat quickly like Leaches," and until their real nature was known they were thought to be worms. This and other facts prove, that, in the Worm, the vitality of the animal is very equally distributed to each ring. If we cut off the head or tail of some of the low worms, such as the Flat Worms (*Planaria*, etc.), the pieces will become a distinct animal, but an Insect or Crab sooner or later dies when deprived of its head or tail (abdomen).

Thus, in the Worm the vital force is very equally distributed to each zoölogical element, or ring of the body; no single part of the body is much honored above the rest, so as to subordinate and hold the other parts in subservience to its peculiar and higher ends in the animal economy.

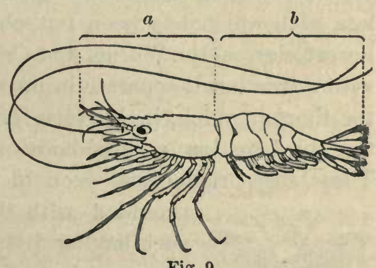


Fig. 9.

The Crustacean, of which the Shrimp (Fig. 9) is a typical example, is composed of a determinate number (21) of rings which are gathered into two regions; the head-thorax (cephalothorax) and hind-body, or abdomen. In this class there is a broad distinction between the anterior and posterior ends of the body. The rings are now grouped into two regions, and the hinder division is subordinate in its structure and

FIG. 9. A Shrimp. *Pandalus annulicornis*. *a*, cephalothorax; *b*, abdomen.

uses to the forward portion of the body. Hence the nervous power is transferred in some degree towards the head; the cephalothorax containing the nervous centres from which nerves are distributed to the abdomen. Nearly all the organs performing the functions of locomotion and sensation reside in the front region; while the vegetative functions, or those concerned in the reproduction and nourishment of the animal, are mostly carried on in the hinder region of the body (the abdomen).

The typical Crustacean cannot be said to have a true head, in distinction from a thorax bearing the organs of locomotion, but rather a group of rings, to which are appended the organs of sensation and locomotion. Hence we find the appendages of this region gradually changing from antennæ and jaws to foot-jaws, or limbs capable of eating and also of locomotion; they shade into each other as seen in Fig. 9. Sometimes the jaws become remarkably like claws; or the legs resemble jaws at the base, but towards their tips become claw-like; gill-like bodies are sometimes attached to the foot-jaws, and thus, as stated by Professor J. D. Dana in the introduction to his great work on the Crustacea of the United States Exploring Expedition, the typical Crustaceans do not have a distinct head, but rather a "head-thorax" (cephalothorax).

When we rise a third and last step into the world of Insects, we see a completion and final development of the articulate plan which has been but obscurely hinted at in the two lowest classes, the Worms and Crustaceans. Here we first meet with a true head, separate in its structure and functions from the thorax, which, in its turn, is clearly distinguishable from the third region of the body, the abdomen, or hind-body. These three regions, as seen in the Wasp (Fig. 10), are each provided with three distinct sets of organs, each having distinct functions, though all are governed by and minister to the brain force, now in a great measure gathered up from the posterior rings of the body, and in a more concentrated form (the brain being larger than in the lower articulates) lodged in the head.

Fig. 10.

Here, then, is a centralization of parts headwards; they are

FIG. 10. *Philanthus ventilabris* Fabr. A Wood-wasp.—*From Say.*

brought as if towards a focus, and that focus the head, which is the meaning of the term "cephalization," proposed by Professor Dana.* *Ring* distinctions have given way to *regional* distinctions. The former characterize the Worm, the latter the Insect. In other words, the division of the body into three parts, or regions, is in the insect, on the whole, better marked than the division of any one of those parts, except the abdomen, into rings.

Composition of the Insect-crust. Before describing the composition of the body-wall, or crust, of the Insect, let us briefly review the mode in which the same parts are formed in the lower classes, the Worms and Crustaceans. We have seen that the typical ring, or segment (called by authors *zoönule*, *zoönite*, or *somite*, meaning parts of a body, though we prefer the term *arthromere*, denoting the elemental part of a jointed or articulate animal), consists of an upper (tergite), a side (pleurite), and an under piece (sternite). This is seen in its greatest simplicity in the Worm (Fig. 2), where the upper and ventral arcs are separated by the *pleural region*. In the Crustacean the parts, hardened by the deposition of chitine and therefore thick and unyielding, have to be farther subdivided to secure the necessary amount of freedom of motion to the body and legs. The upper arc not only covers the back of the animal, but extends down the sides; the legs are jointed to the *epimera*, or flanks, on the lower arc; the *episternum* is situated between the epimerum and sternum; and the sternum, forming the breast, is situated between the legs. In the adult, therefore, each elemental ring is composed of six pieces. It should, however, be borne in mind that the tergum and ster-

* In two papers on the Classification of Animals, published in the *American Journal of Science and Arts*, Second Series, vol. xxxv, p. 65, vol. xxxvi, July, 1863, and also in his earlier paper on Crustaceans, "the principle of cephalization is shown to be exhibited among animals in the following ways:

1. By a transfer of members from the *locomotive* to the *cephalic* series.

2. By the anterior of the locomotive organs participating to some extent in cephalic functions.

3. By increased abbreviation, concentration, compactness, and perfection of structure, in the parts and organs of the anterior portion of the body.

4. By increased abbreviation, condensation, and perfection of structure in the posterior, or gastric and caudal portion of the body.

5. By an upward rise in the cephalic end of the nervous system. This rise reaches its extreme limit in Man."

num each consist, in the embryo, of two lateral parts, or halves, which, during development, unite on the median line of the body. Typically, therefore, the crustacean ring consists primarily of eight pieces. The same number is found in all insects which are wingless, or in the larva and pupa state; this applies also to the Myriapods and Spiders.

In the Myriapoda, or Centipedes, the broad tergum overlaps the small epimera, while the sternum is much larger than in the Spiders and Insects. In this respect it is like the broad flat under-surface of most worms. Hence the legs of the Centipede are inserted very far apart, and the "breast," or sternum, is not much smaller than the dorsal part of the crust. In the *Julus* the dorsal piece (tergum) is greatly developed over the sternum, but this is a departure from what is apparently the more typical form of the order, *i. e.* the Centipede. In the Spiders there is a still greater disproportion in size between the tergum and the sternum, though the latter is very large compared with that of Insects. The epimera and episterna, or side-pieces of the Spiders, are partially concealed by the over-arching tergum, and they are small, since the joints of the legs are very large, Audouin's law of development in Articulates showing that one part of the insect crust is always developed at the expense of the adjoining part. In the Spider we notice that the back of the thorax is a single solid plate consisting originally of four rings consolidated into a single hard piece. In like manner the broad solid sternal plate results from the reunion of the same number of sternites corresponding, originally, to the number of thoracic legs. Thus the whole upper side of the head and thorax of the Spider is consolidated into a single hard horny immovable plate, like the upper solid part of the cephalothorax of the Crab or Shrimp. Hence the motions of the Spiders are very stiff compared with those of many Insects, and correspond to those of the Crab.

The crust of the winged insect is modified for the performance of more complex motions. It is subdivided in so different a manner from the two lower orders of the class, that it would almost seem to have nothing in common, structurally speaking, with the groups below them. It is only by examin-

ing the lowest wingless forms such as the Louse, Flea, *Podura*, and Bark-lice, where we see a transition to the Orders of Spiders and Myriapods, that we can perceive the plan pervading all these forms, uniting them into a common class.

A segment of a winged six-footed insect (Hexapod) consists typically of eight pieces which we will now examine more leisurely. Figure 12 represents a side-view of the thorax of the *Telea Polyphemus*, or Silk-worm moth, with the legs and wings removed. Each ring consists primarily of the *tergum*, the two side-pieces (epimerum and episternum) and the *sternum*, or breast-plate. But one of these pieces (sternum) remains simple, as in the lower orders. The tergum is divided into four pieces. They were named by Audouin going from before backwards, the *præscutum*, *scutum*, *scutellum*, and *postscutellum*.

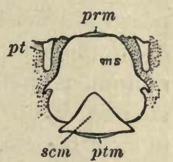


Fig. 11.

The scutum is invariably present and forms the larger part of the upper portion (tergum) of the thorax; the scutellum is, as its name indicates, the little shield so prominent in the beetle, which is also uniformly present. The other two pieces are usually minute and crowded down out of sight, and placed between the two opposing rings. As seen in Fig. 11, the præscutum of the moth is a small rounded piece, bent vertically down, so as not to be seen from above. In the lowly organized *Hepialus*, and some

Fig. 12.

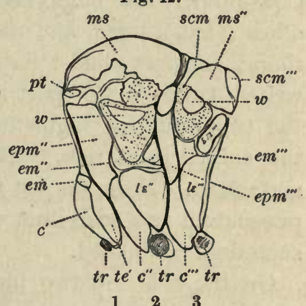


Fig. 11. Tergal view of the middle segment of the thorax of *Telea Polyphemus*. *prm*, præscutum; *ms*, scutum; *scm*, scutellum; *ptm*, postscutellum; *pt*, patagium, or shoulder tippet, covering the insertion of the wings. — *Original.*

Fig. 12. Side view of the thorax of *T. Polyphemus*, the hairs removed. 1, Prothorax; 2, Mesothorax; 3, Metathorax, separated by the wider black lines. Tergum of the prothorax not represented. *ms*, mesoscutum; *scm*, mesoscutellum; *ms''*, metascutum; *scm'''*, metascutellum; *pt*, a supplementary piece near the insertion of patagia; *w*, pieces situated at the insertion of the wings and surrounded by membrane; *em*, epimerum of prothorax, the long upright piece above being the episternum; *epm''*, episternum of the mesothorax; *em''*, epimerum of the same; *epm'''*, episternum of the metathorax; *em'''*, epimerum of the same, divided into two pieces; *c'*, *c''*, *c'''*, coxæ; *te'*, *le''*, *le'''*, trochantines; *tr*, *tr*, *tr*, trochanters. — *Original.*

Neuroptera, such as the *Polystœchotes* (Fig. 13 *a*), the præscutum is large, well developed, triangular, and wedged in between the two halves of the scutum. The little piece succeeding the scutellum, *i.e.* the postscutellum, is still smaller, and rarely used in descriptive entomology. Thus far we have spoken of the middle, or mesothoracic, ring, where these four pieces are most equally developed. In the first, or prothoracic, ring, one part, most probably the scutum, is well developed, while the others are aborted, and it is next to impossible to trace them in most insects. The prothorax in the higher insects, such as the Hymenoptera, Lepidoptera, and Diptera is very small, and often intimately soldered to the succeeding or mesothoracic ring. In the lower insects, however, such as the Coleoptera, the bugs (Hemiptera), grasshoppers and their allies (Orthoptera), and the Neuroptera, the large broad prothorax consists almost entirely of this single piece, and most writers speak of this part under the name of "thorax," since the two posterior segments are concealed by the wings when the animal is at rest. The *metathorax* is usually very broad and short. Here we see the scutum split asunder, with the præscutum and scutellum wedged in between, while the postscutellum is aborted.

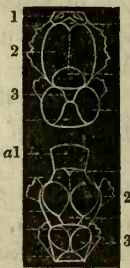


Fig. 13.

On the side are two pieces, the upper (epimerum) placed just beneath the tergum, which is the collective name for the four tergal, or dorsal, pieces enumerated above. In front of the epimerum and resting upon the sternum, as its name implies, is the *episternum*. These two parts (pleurites) compose the flanks of the elemental ring. To them the legs are articulated. Between the two episterna is situated the breast-piece (sternum), which shows a tendency to grow smaller as we ascend from the Neuroptera to the Bees.

In those insects provided with wings, the epimera are also subdivided. The smaller pieces, hinging upon each other, as it were, give play to the very numerous muscles of flight

FIG. 13. A tergal view of thorax of *Hepialus* (*Sthenopis*); 1, prothorax; 2, mesothorax; 3, metathorax. The prothorax is very small compared with that of *Polystœchotes* (13 *a*, 1), where it is nearly as long as broad.—*Original.*

needed by the insect to perform its complicated motions while on the wing.

The insertion of the fore wing is concealed by the "shoulder tippets," or *patagia* (Fig. 11), which are only present in the mesothorax. The external opening of the spiracles just under the wing perforates a little piece called by Audouin the *peritreme.*

A glance at Figures 11 and 12 shows how compactly the various parts of the thorax are agglutinated into a globular mass, and that this is due to the diminished size of the first and third rings, while the middle ring is greatly enlarged to support the muscles of flight. There are four tergal, four pleural, two on each side (and these in the Hymenoptera, Lepidoptera, and Diptera subdivide into several pieces), and a single sternal piece, making nine for each ring and twenty-seven for the whole thorax, with eight accessory pieces (the three pairs of *peritremes* and the two *patagia*), making a total of thirty-five for the entire thorax; or, multiplying the four tergal pieces by two, since they are formed by the union of two primitive pieces on the median line of the body, we have thirty-nine pieces composing the thorax.

Table of the Parts of the Thorax applied to the Pro-, Meso-, and Metathorax, respectively.

Thorax	Dorsal Surface	Præscutum, Scutum, Scutellum, Postscutellum.
	Pleural Surface	Epimerum, Episternum, Episternal apophysis, Stigma, Peritreme.
	Sternal Surface	Sternum.

We must remember that these pieces are rarely of precisely the same form in any two species, and that they differ, often in a very marked way, in different genera of insects. How simple, then, is the typical ring, and how complex are the various subdivisions of that ring as seen in the actual, living insect, where each part has its appropriate muscles, nerves, and tracheæ!

We have seen how the thorax is formed in Insects generally, let us now advert to the two types of thorax in the six-footed

insects. In the higher series of suborders, comprising the Diptera, Lepidoptera and Hymenoptera, placing the highest last, the thorax shows a tendency to assume a globular shape; the upper side, or tergum, is much arched, the pleural region bulges out full and round, while the legs conceal at their insertion the sternum which is minute in size.

In the lower series, embracing the Coleoptera, Hemiptera, Orthoptera, and Neuroptera, the entire body tends to be more flattened; in the thorax the tergum is broad, especially that of the prothorax, while the pleurites (episterna and epimera) are short and bulge out less than in the higher series, and the sternum is almost invariably well developed, often presenting a large thick breast-plate bearing a stout spine or thick tubercle, as in *Œdipoda*. We can use these characters, in classifying insects into suborders, as they are common to the whole order. Hence the use of characters drawn from the wings and mouth-parts (which are sometimes wanting), leads to artificial distinctions, as they are *peripheral* organs, though often convenient in our first attempts at classifying and limiting natural groups.

The abdomen. In the hind body, or third region of the trunk, the three divisions of the typical ring (arthromere), are entire, the tergum is broad and often not much greater in extent than the sternum; and the pleurites also form either a single piece, or, divided into an epimerum and episternum, form a distinct lateral region, on which the stigmata are situated. The segments of the abdomen have received from Lacaze-Duthiers a still more special name, that of *urite*, and the different tergal pieces belonging to the several rings, but especially those that have been modified to form the genital armor have been designated by him as *tergites*. We have applied this last term to the tergal pieces generally. The typical number of abdominal segments is eleven. In the lowest insects, the Neuroptera, there are usually eleven; as we have counted them in the abdomen of the embryo of *Diplax*. In others, such as the Hymenoptera and Lepidoptera, there may never be more than ten, so far as present observation teaches us.

The formation of the sting, and of the male intromittent organ, may be observed in the full-grown larva and in the in-

complete pupa of the Humble-bee, and other thin-skinned Hymenopterous larvæ, and in a less satisfactory way in the young Dragon-flies.

If the larva of the Humble-bee be taken just after it has become full-fed, and as it is about to enter upon the pupa state, the elements (*sterno-rhabdites* Lacaze-Duthiers), or tubercles, destined to form the ovipositor, lie in separate pairs, in two groups, exposed distinctly to view, as in Figures 14–18. The ovipositor thus consists of three pairs of slender non-articulated tubercles, situated in juxtaposition on each side of the mesial line of the body. The first pair arises from the eighth abdominal ring, and the second and third pair grow out from the ninth ring. The ends of the first pair scarcely reach beyond the base of the third pair. With the growth of the semi-pupa, the end of the abdomen decreases in size, and is

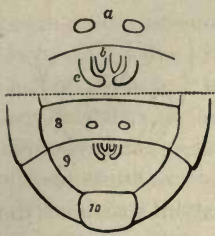


Fig. 14.

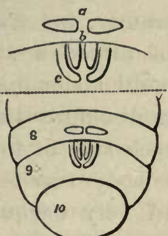


Fig. 15.

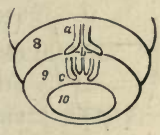
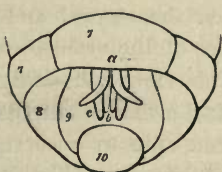
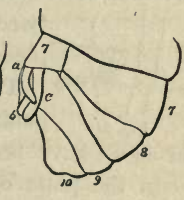


Fig. 16.

Fig. 17.



17*a*.



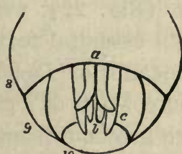
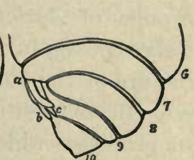


Fig. 18.



18*a*.

FIG. 14. Rudiments of the sting, or ovipositor, of the Humble-bee. 8, 9, 10, sternites of eighth, ninth, and tenth abdominal rings in the larva. *a*, first pair, situated on the eighth sternite; *b*, second and inner pair; and *c*, the outer pair. The lettering is the same in figures 14–22. The inner pair (*b*), forms the true ovipositor, through which the eggs are supposed to pass when laid by the insect, the two outer pairs, *a* and *c*, sheathing the inner pair.

FIG. 15. The same a little farther advanced.

FIG. 16. The same at a later stage, the three pairs approximating.

FIG. 17. The three pairs now appear as if together growing from the base of the ninth segment; 17*a*, side view of the same, showing the end of the abdomen growing smaller through the diminution in size of the under side of the body.

FIG. 18. The three pairs of rhabdites now nearly equal in size, and nearly ready to unite and form a tube; 18*a*, side view of the same; the end of the abdomen still more pointed; the ovipositor is situated between the seventh and tenth rings, and is partially retracted within the body.

gradually incurved toward the base (Fig. 18), and the three pairs of rhabdites approach each other so closely that the two outer ones completely ensheath the inner, until a complete extensible tube is formed, which is gradually withdrawn entirely within the body.

The male genital organ is originally composed of three pairs (two pairs, apparently, in *Æschna*, Fig. 19) of tubercles all arising from the *ninth* abdominal ring, being sternal outgrowths and placed on each side of the mesial line of the body, two being anterior, and very unequal in size, and the third pair nearer the base of the abdomen. The external genital organs cannot be considered as in any way homologous with the limbs, which are articulated outgrowths budding out between the sternal and pleural pieces of the *arthromere*.*

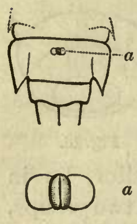


Fig. 19.

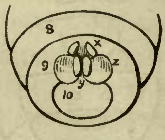


Fig. 20.

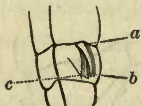


Fig. 21.

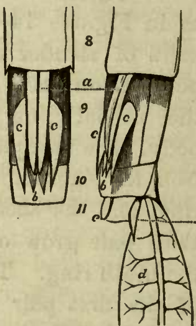


Fig. 22.

This view will apply to the genital armor of all Insects, so far as we have been able to observe. It is so in the pupa of *Æschna* (Fig. 21), and the pupa of *Agrion* (Fig. 22), which completely repeats, in its essential features, the structure of the ovipositor of *Bombus*. Thus in *Æschna* and *Agrion* the ovipositor consists of a pair of closely appressed ensiform processes which grow out from under the posterior edge of the eighth abdominal ring, and are embraced between two pairs

* This term is proposed as better defining the ideal ring, or primary zoölogical element of an articulated animal than the terms *somite* or *zoönite*, which seem too vague; we also propose the term *arthroderm* for the outer crust, or body walls, of Articulates, and *arthropleura* for the pleural, or limb-bearing region, of the body, being that portion of the arthromere situated between the tergite and sternite.

FIG. 19. The rudiments of the male intromittent organ of the pupa of Æschna, consisting of two flattened tubercles situated on the ninth ring; the outer pair large and rounded inclosing the smaller linear oval pair.

FIG. 20. The same in the Humble-bee, but consisting of three pairs of tubercles, *x*, *y*, *z*; 8, 9, 10, the last three segments of the abdomen.

FIG. 21. The rudimentary ovipositor of the pupa of *Æschna*, a Dragon-fly.

FIG. 22. The same in pupa of *Agrion*, a small Dragon-fly. Here the rudiments of the eleventh abdominal ring is seen. *d*, the base of one of the abdominal false gills.—*Figs.* 14–22 *original.*

of thin lamelliform pieces of similar form and structure, arising from the sternite of the ninth ring. These sternal outgrowths do not homologize with the filiform, antennæ-like, jointed appendages of the eleventh ring, as seen in the Perlidæ and most Neuroptera and Orthoptera (especially in *Mantis tessellata* where they (Fig. 23) closely resemble antennæ), which, arising as they do from the arthropleural, or limb-bearing region of the body, *i. e.* between the sternum and episternum, are strictly homologous with the abdominal legs of the Myriapoda, the "false legs" of caterpillars, and the abdominal legs of some Neuropterous larvæ (*Corydalis*, *Phyganeidæ*, *etc.*).

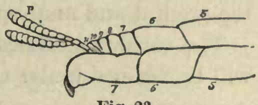


Fig. 23.

It will thus be seen that the attenuated form of the tip is produced by the decrease in size of certain parts, the actual disappearance of others, and the perfection of those parts to be of future use. Thus towards the extremity of the body the pleurites are absorbed and disappear, the tergites overlap on the sternites, and the latter diminish in size and are withdrawn within the body, while the last, or eleventh sternite, entirely disappears.* Meanwhile the sting grows larger and larger, until finally we have the neatly fashioned abdominal tip of the bee concealing the complex sting with its intricate system of visceral vessels and glands.

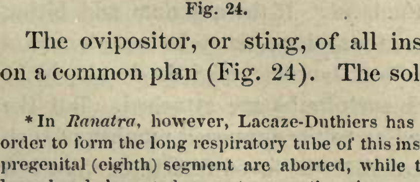


Fig. 24.

The ovipositor, or sting, of all insects, therefore, is formed on a common plan (Fig. 24). The solid elements of the arthro-

*In *Ranatra*, however, Lacaze-Duthiers has noticed the curious fact that in order to form the long respiratory tube of this insect, the tergite and sternite of the pregenital (eighth) segment are aborted, while the pleurites are enormously enlarged and elongated, so as to carry the stigmata far out to the end of the long tube thus formed.

FIG. 23. End of the abdomen of *Mantis tessellata*; *p*, many-jointed anal style resembling an antenna. 5–11, the seven last abdominal segments; the 8–11th sternites being obsolete.—*From Lacaze-Duthiers.*

FIG. 24. Ideal plan of the structure of the ovipositor in the adult insect. 1–7t, the tergites, connected by dotted lines with their corresponding sternites. *b*, the eighth tergite, or anal scale; *c*, epimerum; *a′*, *a*, two pieces forming the outer pair of rhabdites; *i*, the second pair, or stylets; and *f*, the inner pair, or sting; *d*, the

mere are modified to form the parts supporting the sting alone. The external opening of the oviduct is always situated between the eighth and ninth segments, while the anal opening lies at the end of the eleventh ring. So that there are really, as Lacaze-Duthiers observes, three segments interposed between the genital and anal openings.

The various modifications of the ovipositor and male organ will be noticed under the different suborders.

THE STRUCTURE OF THE HEAD. After studying the composition of the thorax and abdomen, where the constituent parts of the elemental ring occur in their greatest simplicity, we may attempt to unravel the intricate structure of the head. We are to determine whether it is composed of one; or more, segments, and if several, to ascertain how many, and then to learn what parts of the typical arthromere are most largely developed as compared with the development of similar parts in the thorax or abdomen. In this, perhaps the most difficult problem the entomologist has to deal with, the study of the head of the adult insect alone is only guesswork. We must trace its growth in the embryo. Though many writers consider the head as consisting of but a single segment, the most eminent entomologists have agreed that the head of insects is composed of two or more segments. Savigny led the way to these discoveries in transcendental entomology by stating that the appendages of the head are but modified limbs, and homologous with the legs. This view at once gave a clue to the complicated structure of the head. If the antennæ and biting organs are modified limbs, then there must be an elemental segment present in some form, however slightly developed in the mature insect, to which such limbs are attached. But the best observers have differed as to the supposed number of such theoretical segments. Burmeister believed that there were two only; Carus and Audouin thought there were three; McLeay and Newman four, and Straus-Durckheim recognized seven. From the study of the semipupa of the Humble-bee (*Bombus*)

support of the sting; *e*, the support of the stylet (*i*). *R*, the anus; *O*, the outlet of the oviduct. The seventh, eighth, and ninth sternites are aborted.—*From Lacaze-Duthiers.*

and several low Neuropterous forms, as the larva of *Ephemera*, but chiefly the embryo of *Diplax*, a dragon-fly, we have concluded that there are seven such elemental segments in the head of insects.

That there are four corresponding to the jointed appendages, *i. e.* the labium, or second maxillæ, the first maxillæ, the mandibles, and the antennæ, seems indisputable. But where else are we to look for jointed appendages in an insect's head? We must go out of the class of Insects and study the stalk-eyed Crustacea, such as the Lobster, where the eye is supported on a two-jointed stalk, which has been homologized with the limbs. While, therefore, the eyes of insects are never "stalked," as in the Lobster and Shrimp, they are evidently developed, as in the Crustacean, upon a separate segment (or its rudiments), which may be called the "ophthalmic ring," and which is, therefore, the fifth cephalic ring. In advance of the eyes are normally placed the three ocelli, though in the highest Insects (the Diptera, Lepidoptera, and Hymenoptera) they appear to be situated in the rear of the eyes.

Each of these three ocelli is situated upon a distinct piece; but we must consider the anterior single ocellus as in reality formed of two, since in the immature pupa of Bombus the anterior ocellus is differently shaped from the two posterior ones, being transversely ovate, resulting, as I think, from the fusion of two originally distinct ocelli, and not round like the other two. There are, therefore, two pairs of ocelli, and hence they grow from the rudiments of a sixth and seventh ring respectively.

Now, since the *arthropleural* is the limb-bearing region in the thorax, it must follow that this region is largely developed in the head, to the bulk of which the sensory and digestive organs bear so large a proportion; and as all the parts of the head are subordinated in their development to that of the appendages of which they form the support, it must follow logically that the larger portion of the body of the head is *pleural*, and that the *tergal*, and especially the *sternal*, parts are either very slightly developed, or wholly obsolete. Thus each region of the body is characterized by the relative development of the three parts of the arthromere. In the abdomen the upper

(tergal) and under (sternal) surfaces are most equally developed, while the pleural line is reduced to a minimum. In the thorax the pleural region is much more developed, either quite as much, or often more than the upper, or tergal portion, while the sternal is reduced to a minimum. In the head the pleurites form the main bulk of the region, the sternites are reduced to a minimum, and the tergites may be identified in the occiput, the clypeus, and labrum.

TABLE OF THE SEGMENTS OF THE HEAD AND THEIR APPENDAGES, BEGINNING WITH THE MOST ANTERIOR.*

	Preoral.	
(*Hypothetical*),	Tergal,	Labrum, epipharynx, clypeus.
First Segment (*First Ocellary*),	Pleural,	Anterior ocellus (originally double).
Second Segment (*Second Ocellary*),	Pleural,	Two posterior ocelli.
Third Segment (*Ophthalmic*),	Pleural,	Eyes.
Fourth Segment (*Antennary*),	Pleural,	Antennæ.
	Postoral.	
Fifth Segment (*Mandibular*),	Pleural,	Mandibles.
Sixth Segment (*First Maxillary*),	Pleural,	First maxillæ.
Seventh Segment (*Second Maxillary, or Labial*),	Tergal (occiput), Pleural (gena), Sternal (gula),	Second maxillæ (Labium).

The Appendages. We naturally begin with the thoracic appendages, or *legs*, of which there is a pair to each ring. The leg (Fig. 25) consists of seven joints, the basal one, the *coxa*, in the Hymenoptera, Lepidoptera, and Diptera, consisting of two

* In the first column are enumerated the seven rings, or segments, composing the head. The tergal parts (*i.e.* the labrum, epipharynx, and clypeus), situated in front of the ocelli, are left out in enumerating the seven segments, as they are not supposed by the author to belong to either of those segments.

In the first column the seven rings are named (in brackets) according to the sort of appendages they bear. In the second column is given the part, or parts, of the ideal segment supposed actually to exist in an insect's head; and in the third column are to be found the names of the organs attached to their corresponding segments, beginning with the front and going back to the base of the head.

pieces, *i.e.* the coxa and *trochantine* (see Fig. 12); the *trochanter;* the *femur;* the *tibia*, and, lastly, the *tarsus*, which is subdivided into from one to five joints, the latter being the normal number. The terminal joint ends in a pair of claws between which is a cushion-like sucker called the *pulvillus.* This sucking disk enables the Fly to walk upside down and on glass.

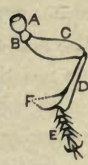


Fig. 25.

In the larva, the feet are short and horny, and the joints can be still distinguished. In Myriapods, each segment of the abdomen has a pair of feet like the thoracic ones. We must consider the three pairs of spinnerets of Spiders, which are one to three-jointed, as homologous with the jointed limbs of the higher insects. In the six-footed insects (Hexapoda), the abdominal legs are deciduous, being present in the Coleopterous grub, the Dipterous maggot, the caterpillar, and larva of the Saw-fly, but disappearing in the pupa state. They are often, as in most maggots, either absent, or reduced in number to the two anal, or terminal, pair of legs; while in the Saw-flies, there are as many as eight pairs. These "false" or "prop-legs" are soft and fleshy, and without articulations. At the retractile extremity is a crown of hooks, as seen in caterpillars or the hind-legs of the larva of *Chironomus* (Fig. 26), in which the prothoracic pair of legs is reduced to inarticulate fleshy legs like the abdominal ones.

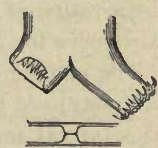


Fig. 26.

The *position* of the different pairs of legs deserves notice in connection with the principle of "antero-posterior symmetry." The fore-legs are directed forwards like the human arms, but the two hinder pairs are directed backwards. In the Spiders, three pairs of abdominal legs (spinnerets) are retained throughout life; in the lower Hexapods, a single pair, which is appended to the eleventh segment, is often retained, but under a form which is rather like an antenna, than limb-like. In some Neuropterous larvæ (*Phryganea*, *Corydalus*, etc.) the anal pair of limbs are very well marked; they constitute the "anal forceps" of the adult insect. They sometimes become true, many-jointed appendages, and are then remarkably like

FIG. 25. A, coxa; B, trochanter; C, femur; D, tibia; F, tibial spurs; E, tarsus, divided into five tarsal joints, the fifth ending in a claw.—*From Sanborn.*

antennæ, as in the instance of *Mantis tessellata* described by Lacaze-Duthiers (Fig. 23). In the Cockroach these appendages, sometimes called "anal cerci," resemble the antennæ of the same insect. In the Lepidoptera and Hymenoptera they do not appear to be jointed, and are greatly aborted.

The Wings. The wings of insects first appear as little soft vascular sacs permeated by tracheæ. They grow out in the preparatory stages (Fig. 27) of the pupa from the side of the thorax and above the insertion of the legs, *i.e.* between the epimerum and tergum. During the pupa state they are pad-like, but when the pupa skin is thrown off they expand with air, and in a few minutes, as in the Butterfly, enlarge to many times their original size. The wings of insects, then, are simple expansions of the crust, spread over a framework of horny tubes. These tubes are really double, consisting of a central trachea, or air tube, inclosed within a larger tube filled with blood, and which performs the functions of the veins. Hence the aëration of the blood is carried on in the wings, and thus they serve the double purpose of lungs and organs of flight.

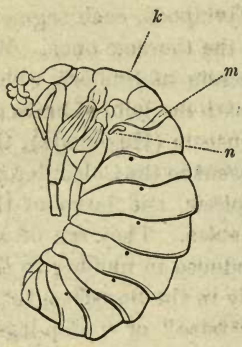


Fig. 27.

The number and situation of these veins and their branches (veinlets) are of great use in separating genera and species. The typical number of primary veins is five. They diverge outward at a slight angle from the insertion of the wing, and are soon divided into veinlets, from which cross veins are thrown out connecting with others to form a net-work of veins and veinlets, called the *venation* of the wing (Figs. 28, 29). The interspaces between the veins and veinlets are called *cells*.

At a casual glance the venation seems very irregular, but in many insects is simple enough to enable us to trace and name the veinlets. The five main veins, most usually present, are

FIG. 27. The semipupa of *Bombus*, the larva skin having been removed, showing the two pairs of rudimentary wings growing out from the mesothorax (*k*), and metathorax (*m*). *n* and the seven succeeding dots represent the eight abdominal stigmata, the first one (*n*) being in the pupa situated on the thorax, since the first ring of the abdomen is in this stage joined to the thorax. — *Original.*

called, beginning at the *costa*, or front edge, the *costal*, *subcostal*, *median*, *submedian*, and *internal*, and sometimes the median divides into two, making six veins. The costal vein is undivided; the subcostal and median are divided into several branches, while the submedian and internal are usually simple.

The venation of the fore-wings affords excellent marks in separating genera, but that of the hind wings varies less, and is consequently of less use.

The wings of many insects are divided by the veins into three well-marked areas; the *costal*, *median*, and *internal*. The costal area (Fig. 31 *b*) forms the front edge of the wing and is the strongest, since the veins are nearer together than elsewhere, and thus afford the greatest resistance to the air

Fig. 28.

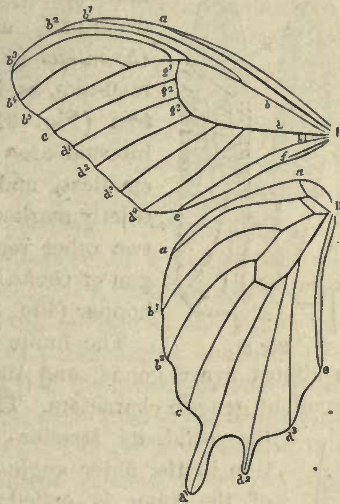


Fig. 29.

FIG. 28. Fore and hind wings of a Butterfly, showing the venation. I. fore wing: *a*, costal vein; *b*, subcostal vein; *b* 1, *b* 2, *b* 3, *b* 4, *b* 5, five subcostal veinlets; *c*, independent vein (it is sometimes a branch of the subcostal, and sometimes of the median vein); *d*, median vein; *d* 1, *d* 2, *d* 3, *d* 4, four median veinlets; *e*, submedian vein; *f*, internal vein; *h*, interno-median veinlet (rarely found, according to Doubleday, except in Papilio and Morpho); *b* and *d* are situated in the "discal cell;" *g* 1, *g* 2, *g* 3, the upper, middle, and lower discal veinlets. In the Bombycidæ and many other moths *g* 1 and *g* 2 are thrown off from the subcostal and median veins respectively, meeting in the middle of the cell at *g* 2. They are sometimes wholly absent.

II. The hind wing; the lettering and names of the veins and veinlets the same as in the fore wing.—*Slightly changed from Doubleday.*

FIG. 29. Fore wing of a Hymenopterous insect. *c*, costal vein; *sc*, subcostal vein; *m*, median vein; *sm*, submedian vein; *i*, internal vein; c, 1, 2, 3, the first, second, and third costal cells; the second frequently opaque and then called the *pterostigma*. *sc*, 1, 2, 3, 4, the four subcostal cells; *m*, 1, 2, 3, 4, the median cells; *sm*, 1, 2, 3, the three submedian cells; *i* 1, the internal cell; this is sometimes divided into two cells, and the numbers of all but the costal cells is inconstant, the outer row of cells (4, 4, 3) being the first to disappear.

The *costal edge* extends from *c* to *c*; the outer *c*, the *apex*; the *outer edge* extends from the apex (*c*) to *a*, and the *inner edge* extends from *a*, the inner angle, to the insertion of the wing at *i*.—*Original.* Figs. 30–32 *from Scudder.*

during flight. The median area (Fig. 31 *a*) is the largest. It is in the grasshoppers and crickets sometimes modified to form a musical organ, being drum-like, as in the *Œcanthus* (Fig. 30), or rasp-like, as in *Archyptera* (Fig. 31 *a*). The internal area (*c*) is the smallest, and less distinctly marked than the two other regions; the musical file-like organ of *Orchelimum vulgare*, a common grasshopper (Fig. 32 *d*) is situated on this area.

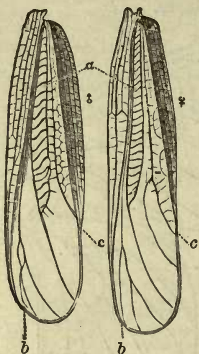


Fig. 31.

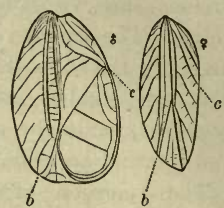


Fig. 30.

The limits of the edges of the wing vary in almost every genus, and their comparative length afford excellent generic characters. The front edge (Fig. 29) is called the *costal*, its termination in the outer angle of the wing is called the *apex;* the *outer edge* is situated between the apex and the *inner angle*, between which and the base of the wing is the inner, or *internal*, edge. These distinctions are of most use in describing the butterflies and moths.

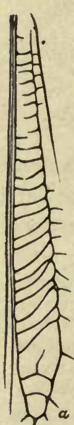


Fig. 31 *a*.

The Appendages of the Head. These organs are divided into two groups, the first of which comprise the sensory organs, *i. e.* the ocelli, eyes, and antennæ, which are attached to the region in front of the mouth, or *preoral* region of the head. The second group consists of the sensorio-digestive appendages, combining the power of finding and seizing the food and preparing it for digestion. They are inserted behind the mouth and belong to the *postoral* region of the head.

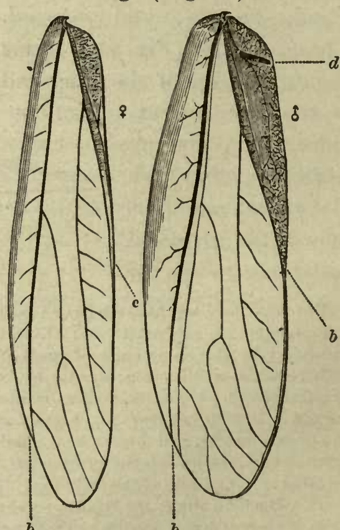


Fig. 32.

We will first describe the ocelli, which are theoretically the most anterior organs of the head, ending with the basal appendages, the labium (second maxillæ) being the hindermost.

The simple eye, *Ocellus*, or *Stemma*, is the simplest form of the eye. Its most elementary form (seen in the larva of the Bot-fly and the Cecidomyian larva of *Miastor*) is that of a brown spot, or group of pigment-cells lodged under the skin and against which a nerve-filament impinges. Over this spot Newport states that the tegument is transparent and convex, resembling a true cornea, or eye-lens. A well-developed ocellus consists, according to Newport, of a "very convex, smooth, single cornea, beneath which is a spherical crystalline lens, resting upon the plano-convex surface of the expanded vitreous humor, the analogue of the transparent cones of the compound eyes." Müller believes that the function of the ocelli is the perception of nearer objects, while that of the compound eyes is to see more distant objects. The ocelli constitute the only visual organs in the Myriapods (except *Cermatia*), the Arachnida, and the larvæ of many Six-footed Insects; they are usually from one to six on a side. In adult insects they are generally three in number, and are generally present except in the large majority of Coleoptera. Their *normal* site is in front of the eyes, but they are usually thrown back, during the growth of the insect, behind the eyes, on the vertex, or topmost part of the head (Fig. 33).

Fig. 33.

The Compound Eyes are a congeries of simple eyes. During the growth of the insect the simple eyes of the larva increase in number, and finally coalesce to form the compound eye, or compound cornea, the surface of which is very convex and protuberant in the predaceous insects, or those requiring an extended field of vision.

Fig. 34.

The number of facets, or corneæ, vary from fifty (in the Ant) to 3,650, the latter number being counted by Geoffroy in the eye of a Butterfly. These facets are usually hexagonal, as in the Dragon-fly (Fig. 34), or, rarely, quadrangular.

FIG. 33. Ocelli of three species of Sand-wasps, *Pompilus.*—*From Cresson.*

FIG. 34. Three hexagonal facets of the compound eye of a fossil Dragon-fly, greatly magnified.—*From Dawson.*

The *Antennæ* (Figs. 35, 36) are inserted usually in the adult insect between, or in front of the eyes, though normally the antennary is posterior to the ophthalmic ring. It is normally a long, filiform, slender, many-jointed appendage, undergoing great changes in form. When it is highly specialized, as in Coleoptera and Hymenoptera, it is divided into three parts, the basal or *scape*, the middle or *pedicel*, and the terminal part or *flagellum*, or *clavola*, which usually comprises the greater part of the antenna.


Fig. 35.

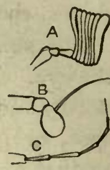


Fig. 36.

It is believed by some that the sense of hearing is lodged in the antennæ, though Siebold has discovered an auditory apparatus situated at the base of the abdomen of some, and in the fore-legs of other species of Grasshoppers.

Mr. J. B. Hicks has made the latest studies on the auditory apparatus. According to him "it consists first of a cell, sac, or cavity filled with fluid, closed in from the air by a membrane analogous to that which closes the *foramen ovale* in the higher animals; second, that this membrane is, for the most part, thin and delicate, but often projects above the surface, in either a hemispherical, conical, or canoe-shaped, or even hair-like form, or variously marked; thirdly, that the antennal nerve gives off branches which come in contact with the inner wall of the sacs; but whether the nerve enters, or, as is most probable, ends in the small internally projecting papilla which I have shown to exist in many of these sacs, it is very difficult to say. The principal part of the nerve proceeds to these organs, the remaining portion passing to the muscles, and to the roots of the hairs, at least to those of the larger sort." On the other hand, Lefebvre, Leydig, and Gerstaecker regard this so-called "auditory apparatus" as an organ of smell.

The antennæ have also the sense of touch, as may readily be observed in Ants, Bees, and the Grasshopper and Cockroach. "The Honey-bee, when constructing its cells, ascertains their proper direction and size by means of the extremities of these

FIG. 35. Filiform antenna of *Amphizoa.—From Horn.*

FIG. 36. A, lamellate antenna of a Lamellicorn Beetle; B, antenna of a Fly, with the bristle thrown off from the terminal joint; C, bristle-like antenna of a Dragon-fly, *Libellula.—From Sanborn.*

organs; while the same insect, when evidently affected by sounds, keeps them motionless in one direction, as if in the act of listening." (Newport.)

After cutting off one or both antennæ of the June beetle, *Lachnosterna*, the insect loses its power of directing its flight or steps, wheeling about in a senseless manner. Dr. Clemens observed that the Cecropia moth was similarly affected after losing its antennæ.

The Mandibles (Fig. 37) are inserted on each side of the mouth-opening. They usually consist of but a single joint,

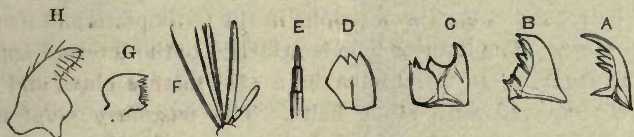


Fig. 37.

representing probably the basal part of the ideal limb. This part, however, is often subdivided by two longitudinal furrows into three parts, each ending in a "tooth" of unequal size for tearing and cutting the food. This tripartite form of the mandibles, to which attention has been called by Mr. Scudder, is more fully carried out in the maxilla, where each portion is highly specialized. The mandibles vary greatly in form and size. The two cutting edges are usually opposed to each other, or frequently overlap in the carnivorous forms. Their base is often concealed by the clypeus and labrum. Their motion is transverse, being the reverse of the motion of the jaws of Vertebrates.

a Fig. 38. *b*

Fig. 39.

The Maxillæ (Figs. 38 *b*, 39) are much more complicated organs than the mandibles. They are

FIG. 37. Different forms of mandibles. A, mandible of *Cicindela purpurea*; B, *Phylloptera*, a green grasshopper; C, *Libellula trimaculata*; D, *Vespa maculata*, or paper-making Wasp; E, "rostrum" or jointed sucker of the Bed-bug, *Cimex lectularius*, consisting of mandibles, maxillæ, and labium; F, proboscis, or sucker, of a Mosquito, *Culex*, in which the mandibles are long and bristle-like.— *From Sanborn.* G, mandible of *Amphizoa*; H, mandible of *Acratus*, a genus of Cockchafers.— *From Horn.*

FIG. 38. *a*, mentum and labial palpi; *b*, one maxilla, with its palpus, of *Acratus*.— *From Horn.*

FIG. 39. Maxilla of *Amphizoa*, with the two lobes (stipes and lacinia), and the palpifer bearing the four-jointed palpus.— *From Horn.*

inserted on the under side of the head and just behind the mouth. The maxilla consists of a basal joint, or *cardo*, beyond which it is subdivided into three lobes, the *stipes*, or footstalk; the *palpifer*, or palpus-bearer; and the *lacinia*, or blade. The stipes forms the outer and main division of the organ. The lacinia is more membranaceous than the other parts, and its upper surface is covered with fine hairs, and forms a great part of the side of the mouth. It is divided into two lobes, the superior of which is called the *galea*, or helmet, which is often a thick double-jointed organ edged with stiff hairs, and is used as a palpus in the Orthoptera and many Coleoptera. The inferior lobe is attached to the internal angle of the lacinia. It terminates in a stiff minute claw, and is densely covered with stout hairs. The *maxillary palpi* are long, slender, one to four-jointed organs, very flexible and sensitive.

The maxillæ vary greatly in the different groups. Their office is to seize the food and retain it within the mouth, and also to aid the mandibles in comminuting it before it is swallowed. This function reminds us of that of the tongue of vertebrate animals.

The *labium*, or *second maxillæ* (Fig. 40), is placed in front of the *gula*, which forms the under part of the head, and is bounded on each side by the *genæ*, or cheeks, and posteriorly by the occiput. The genæ are bounded laterally by the epicranium and the under side of the eyes. In front are situated the basal parts of the labium, or second maxillæ, which embraces the *submentum* and *mentum* (or labium proper). The labial palpi are inserted into the mentum, but often the latter piece is differentiated into two, the anterior of which takes the name of *palpiger*, called by Dr. Leconte (Smithsonian Miscellaneous Collections) the ligula, and the palpi originate from them. The *ligula* is the front edge of the labium, being the piece forming the under lip. It is often a fleshy organ, its inner surface being continuous

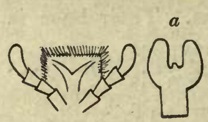


Fig. 40.

FIG. 40. Ligula and labial palpi of *Amphizoa*, an aquatic beetle. It is quadrate and without paraglossæ; *a*, mentum of the same, being deeply incised, and with a tooth at the bottom of the excavation.—*From Horn.*

with the soft membrane of the mouth. In the Bees, it is enormously developed and covered with soft hairs. It is often confounded with the palpiger. In *Hydrous* it is divided into two lobes. In most of the *Carabidæ* and Bees it is divided into three lobes, the two outer ones forming the *paraglossæ* (Fig. 41 *m*), and acting as feelers, while the middle, usually much longer, forms the *lingua*, or tongue, being the continuation of the ligula. In the bees, where the ligula is greatly developed, it performs the part of the tongue in Vertebrates, and aids the maxillæ in collecting nectar and pollen.

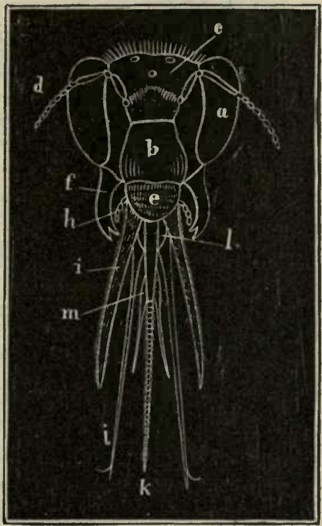


Fig. 41.

The roof of the mouth is formed by the *labrum* and the *epipharynx* (Fig. 42 *c*), a small fleshy tubercle concealed beneath the labrum. It is seen in the bees on turning up the labrum. It probably corresponds to the "labellum" of Schiödte. The labrum (Fig. 41 *e*) is usually transverse and situated in front of the *clypeus* (Fig. 41 *b*). The shield-like *clypeus* is the broad, visor-like, square piece forming usually the front of the head. Behind it is the *clypeus posterior*, or *supra-clypeus*, a subdivision of the clypeus, and especially observable in the Hymenoptera. The *epicranium* forms a large part of the head; it is bounded posteriorly by the *occiput*, on the sides by the eyes, and in front by the clypeus, and though usually described as a single piece, is really composed of several. The ocelli often appear to be situated upon it, though in reality they are placed upon a distinct piece or pieces. The "epicranial suture" is the line of junction of the two "procephalic lobes" (Huxley).

Fig. 41. Front view of the head of a bee, *Anthophora*. *a*, compound eyes; *c*, three simple eyes, situated upon the epicranium; *b*, clypeus; *e*, labrum; *d*, antennæ; *f*, mandibles; *i*, maxillæ; *h*, maxillary palpi; *l*, palpifer; *j*, labial palpi; *m*, paraglossæ; *k*, ligula.—*From Newport.*

(These lobes will be explained farther on when speaking of their development in the embryo.) Behind the epicranium is the *occiput*, or base of the head. It belongs to the labial, or second maxillary segment, and helps to form a complete ring, articulating with the thorax. It is perforated by a foramen to afford a connection between the interior of the head and thorax. It is sometimes, as in many Coleoptera, Orthoptera, and Hemiptera, elongated behind and constricted, thus forming a "neck." It will be seen beyond, that the labrum and clypeus are in the embryo developed from a "tongue-like process whose inferior part eventually becomes the labrum, while superiorly it sends a triangular process (the rudiment of the clypeus) into the interval between the procephalic lobes."* This part (*i.e.* the clypeus and labrum) is the most anterior part of the head, and in the embryo, as in the adult, is normally situated in front of the ocelli, and may be compared with the "anal plate," or eleventh tergite, of the larva.†

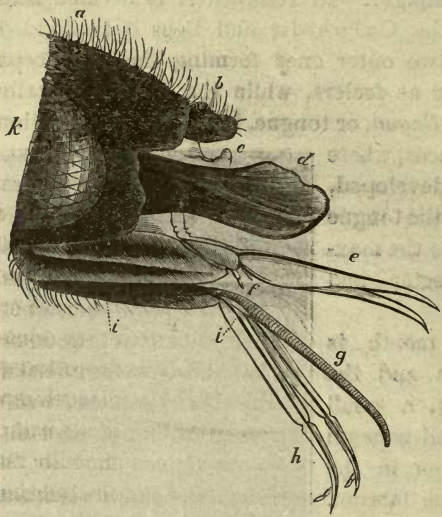


Fig. 42.

FIG. 42. Side view of the front part of the head, together with the mouthparts of the Humble-bee (Bombus). *a*, clypeus covered with hairs; *b*, labrum; *c*, the fleshy epipharynx partially concealed by the base of the mandibles (*d*); *e*, lacinia, or blade of the maxillæ, with their two-jointed palpi (*f*) at the base; *j*, the labium to which is appended the ligula (*g*); below are the labial palpi; *h*, the two basal joints, being greatly enlarged; *k*, the compound eyes.—*Original.*

* These lobes are folded back upon the top of the base of the head, and they seem to form the *tergal* portion of the hypothetical, elemental ring, or rings, to which they respectively belong, and do not seem to us to be the *sternal* portion, as suggested by Huxley, for they are apparently developed in front of the mouth-opening, and form the roof of the mouth.

† "Lastly, there are certain parts developed singly in the median line in the *Articulata.* Of this nature are the frontal spines of *Crustacea*, their telson, and the sting

In describing Insects the *vertex*, or crown, of the head is the highest part; and the *front* is the part usually in front of the insertion of the antennæ.

The Muscular System lies just beneath, and is continuous with the integument. It consists of numerous "distinct isolated straight fibres, which are not gathered into bundles united by common tendons, or covered by aponeuroses [or tendinous sheaths] to form distinct muscles, as in the Vertebrata, but remain separate from each other, and only in some instances are united at one extremity by tendons." (Newport.) These minute fibres form layers, which Newport regards as separate muscles. "Each fibre is composed of a great number of very minute fibrillæ, or fasciculi of fibrillæ," and has been observed by Wagner and Newport to be often striated as in Vertebrates. The muscular system is simplest in the lower insects and the larvæ of the higher forms, and is more complex in the head than elsewhere, and more complex in the thorax than in the abdomen. These minute muscles are exceedingly numerous. "Lyonnet, in his immortal work on the anatomy of the larva of *Cossus ligniperda*, found two hundred and twenty-eight distinct muscles in the head alone, and, by enumerating the fibres in the layers of the different segments, reckoned 1,647 for the body, and 2,118 for the internal organs, thus making together 3,993 muscles in a single larva. In the larva of *Sphinx ligustri* we have found the muscles equally numerous with those discovered by Lyonnet in the Cossus." (Newport.)

The muscular system corresponds to the jointed structure of insects, as do the other internal systems of organs. Of the muscles belonging to a single ring, some stretch from the front edge of one segment to the front edge of the next, and others

of the Scorpion, whose mode of development appears to be precisely similar to that of a telson. In the same category we must rank the labrum in front of the mouth, which in the *Crustacea* (at least) appears to be developed from the sternum of the antennary, or third somite, the metastoma (or so called labium, or lingua) of *Crustacea*, and the lingua of *Insecta*, behind the oral aperture.

"However much these appendages may occasionally simulate, or play the part of appendages, it is important to remember, that, morphologically, they are of a very different nature, and that the confusing them with true appendages must tend completely to obscure the beautiful relations which obtain among the different classes of the *Articulata*."—*Huxley*, Linnæan Transactions, vol. xxii. London.

to the hinder edge; there are also sets of dorsal and ventral muscles going in an oblique or vertical course. The muscles are either colorless and transparent, or yellowish white; and of a soft, almost gelatinous consistence. In form they are simply flat and thin, straight, band-like, or pyramidal, barrel or feather-shaped. They act variously as *rotators*, *elevators*, *depressors*, *retractors*, *protrusors*, *flexors*, and *extensors*.

The *muscular power* of insects is enormous. The Flea will leap two hundred times its own height. Certain beetles can support enormous weights. Newport cites the case of *Geotrupes stercorarius* which is "able to sustain and escape from beneath a pressure of from twenty to thirty ounces, a prodigious weight when it is remembered that the insect itself does not weigh even so many grains." Some beetles have been known to gnaw through lead-pipes, and the Stag-beetle of Europe, *Lucanus cervus*, has, as stated by Mr. Stephens, gnawed "a hole an inch in diameter through the side of an iron canister in which it was confined."

"The *motions* of the insect in walking as in flying are dependent, in the perfect individual, entirely upon the thoracic segments, but in the larva chiefly upon the abdominal. Although the number of legs in the former is always six, and in the latter sometimes so many as twenty-two, progression is simple and easy. Müller states (Elements of Physiology, p. 970, Translation) that on watching insects that move slowly he has distinctly perceived that three legs are always moved at one time, being advanced and put to the ground while the other three propel the body forwards. In perfect insects, those moved simultaneously are the fore and hind feet on one side, and the intermediate foot on the opposite; and afterwards the fore and hind feet on that side, and the middle one on the other, so that, he remarks, in two steps the whole of the legs are in motion. A similar uniformity of motion takes place in the larva, although the whole anterior part of the body is elevated and carried forwards at regular distances, the steps of the insect being almost entirely performed by the 'false,' or abdominal legs."

"In *flight* the motions depend upon the meso- and metathoracic segments conjointly, or entirely upon the former. The

sternal, episternal, and epimeral pieces, freely articulated together, correspond in function with the sternum, the ribs, and the clavicles of birds.* The thorax is expanded and contracted at each motion of the wings, as in birds and other animals, and becomes fixed at each increased effort as a fulcrum or point of resistance upon which the great muscles of the wings are to act, thus identifying this part of the body in function as in structure with that of other animals." (Newport.)

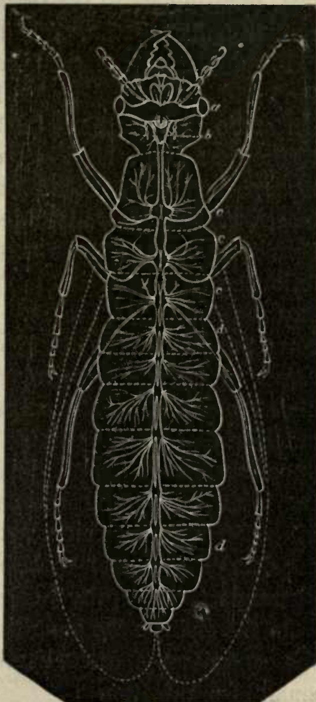


Fig. 43.

THE NERVOUS SYSTEM. In its simplest form the nervous system consists of two longitudinal cords, each with a swelling (nerve-knot, or ganglion,) corresponding to each segment (Fig. 43). This cord lies on the ventral side of the body, but in the head it passes upwards, sending a filament from each side to surround the œsophagus.† As in the Vertebrates, the nervous cord of insects is composed of two distinct columns of fibres placed one upon the other. "The under or *external* column, which is nearest to the exterior of the body, is that in which the ganglia, or enlargements, are situated. The upper one, or that which is *internal* and nearest to the viscera, is entirely without ganglia, and passes directly over the ganglia of the under column without forming part of them, but in very

* Bennet on the Anatomy of the Thorax in Insects, and its Function during Flight. Zoölogical Journal, vol. i, p. 394.

† The brain of insects is formed of several pairs of ganglia, corresponding, probably, to the number of primitive segments composing the head. The nervous cord is thus, in the head, massed together and compacted to form a brain.

FIG. 43. Nervous System of *Corydalus cornutus*. *a*, "cerebrum;" *b*, "cerebrellum;" *c*, thoracic ganglia, which distribute a nerve to each leg; *d*, eight pairs of abdominal ganglia. The dotted lines represent the wings.—*From Leidy*.

close approximation to them." Newport also believes that the ganglionless upper, or internal, column of fibres is analogous to the *motor* column of Vertebrata, while the external, or under one, corresponds to the *sensitive* column, thus representing the cerebro-spinal system of the Vertebrata.

From each pair of ganglia are distributed special nerves to the various organs. In the larva of *Sphinx* the normal number of double ganglia is thirteen, and the nervous cord of the Neuroptera and other lowly organized and attenuated forms of insects corresponds in the main to this number. In the adult insect, especially in the Coleoptera, Diptera, Lepidoptera, and Hymenoptera, the three thoracic ganglia are fused together, following the fusion and general headwise development of the segments of the tegument. Besides the central nervous cord, corresponding to the spinal cord of the Vertebrates, there is a *vagus*, or *visceral nerve*, representing the sympathetic nerve of higher animals. This nerve "arises, in the larva, from the anterior part of the cerebrum, and, forming a ganglion on the upper surface of the pharynx, always passes backward beneath the brain, along the middle line of the œsophagus." In its microscopic structure the nervous cord, like that of Vertebrata, consists of a central "white" substance, and an outer or peripheral part, the "gray" substance.

In the embryo the ganglia are very large and close together, the commissures, or connecting filaments being very short, and small in proportion.

Organs of Nutrition. These consist of the alimentary canal and its appendages, or accessory glands (Fig. 44). We have already treated of the external appendages (mouth-parts) which prepare the food for digestion. The simplest form of the alimentary canal is that of a straight tube. In the larva of *Stylops* and the sedentary young of Bees, it ends in a blind sac, as they live on liquid food and expel no solid excretions. When well developed, as in the adult insect, it becomes a long convoluted thick muscular tube, subdivided into different parts which perform different functions and have distinct names, taken from analogous organs in the vertebrate animals. This digestive tube is composed of three coats, the outer, or *peri-*

toneal; the middle, or *muscular;* and the inner, or *mucous.* The mucous coat is variously modified, being plaited or folded; or,

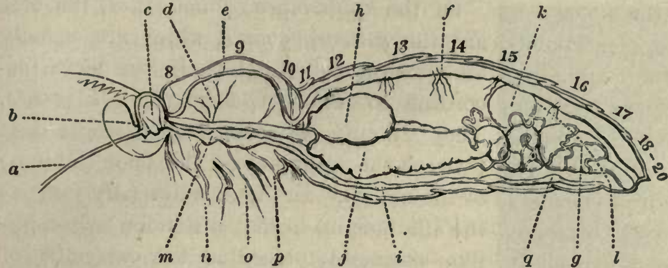


Fig. 44.

as in the Orthoptera and carnivorous Coleoptera, it is solidified and covered with rows of strong horny teeth, forming a sort of gizzard. The alimentary canal is held in place by retractor muscles, but principally by exceedingly numerous branches of the main tracheæ.

This canal (Fig. 45) is subdivided into the *mouth* and *pharynx*, the *œsophagus*, supplementary to which is the *crop*, or "sucking stomach" of Diptera, Lepidoptera, and Hymenoptera; the *proventriculus*, or gizzard; the *ventriculus*, or true stomach, and the intestine, which consists of the *ileum*, or short intes-

FIG. 44. Anatomy of *Sphinx ligustri.* *m*, *i*, *q*, the nervous cord resting on the floor of the body; at *c*, the ganglia form a brain-like organ, much larger than the ganglia of the thorax (*m*) and abdomen (*q*). From the brain is sent off the subœsophageal nerve which surrounds the gullet into which the food is conveyed by the maxillæ, or spiral tongue (*a*), which, when at rest, is rolled up between the labial palpi (*b*).

From the nervous cord is also thrown off a pair of nerves to each pair of legs (as at *n*, *o*, *p*) and a branch, *d*, is sent off from above, distributing nerves to the muscles of flight.

The heart, or dorsal vessel (*e*, *f*), lies just beneath the median line of the body, and is retained in place by muscular bands (as at *f*) as well as by small tracheal branches.

The alimentary canal (*h*, *j*, *g*), forms a straight tube in the head and thorax; *h*, the crop, or sucking stomach, which opens into the œsophagus; *j*, the true, chyle-forming stomach, which contracts posteriorly, and then dilates near its anal outlet into a *cloaca* (indicated at *g*, but not distinctly, as it is concealed by the numerous urinary vessels). The urinary vessels also indicated at *g*, form long tubes (which correspond to the kidneys of Vertebrates), opening into the pyloric end of the stomach. The position of the testes (*k*) is the same as that of the ovary, and the dotted line *l* shows the course of the efferent duct (*vas deferens*) and also of the oviduct of the female.

The numerals indicate the number of segments of the body, which in the Lepidoptera, consists of twenty, the 21st, or 11th abdominal, being absent.—*From Newport.*

tine, and the *colon* and *rectum*. The latter part, as well as the crop and proventriculus, is sometimes absent.

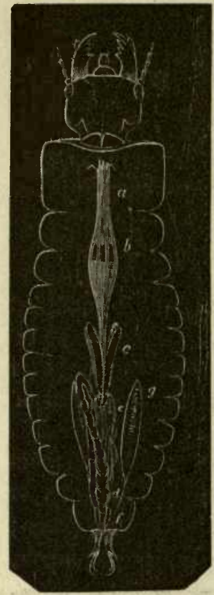


Fig. 45.

Of the *appendages of the canal*, the first are the *salivary glands*, which are usually long simple tubes, which in the larva, according to Newport, form the *silk vessels*. They "empty themselves by a single duct through the spinneret on the floor (labium) of the mouth." In the Ant-lion (*Myrmeleon*) the silk is spun from "a slender telescopic-like spinneret, placed at the extremity of its body," and Westwood also states that the larva of *Chrysopa* spins a cocoon "from the spinneret, at the extremity of the body."

These silk glands when taken out of the larva, just as it is about ready to transform, are readily prepared as "gut" for fish-lines, etc., by drying on a board.

In the Bees these glands are largely developed to produce a sufficient amount of salivary fluid to moisten the dry pollen of flowers, before it enters the œsophagus. "Bee-bread" consists of pollen thus moistened and kneaded by the insect. The Honey-bee also dissolves, by the aid of the salivary fluid, the wax used in making its cells. Newport believes this fluid is alkaline, and forms a solvent for the otherwise brittle wax, as he has seen this insect "reduce the perfectly transparent thin white scales of newly secreted wax to a pasty or soapy consistence, by kneading it between its mandibles, and mixing it with a fluid from its mouth, before applying it to assist in the formation of part of a new cell."

Insects have no true *liver;* its functions being performed "by the walls of the stomach, the internal tunic of which is composed of closely-aggregated hepatic cells." (Siebold.) In the Spiders and Scorpions, however, there is a liver distinct from the digestive canal. In the Spiders it is very large, enveloping most of the other viscera.

Fig. 45. Alimentary tube of *Corydalus cornutus*. *a*, œsophagus; *b*, proventriculus; *c*, ventriculus; *d*, large intestine; *e*, urinary tubes; *f*, cœcum; *g*, testis or ovary.—*From Leidy.*

Siebold states that in some insects the ileum has glandular appendages whose product is perhaps analogous to the *pancreatic fluid.* In the larva of insects is found the *corpus adiposum*, or fat-body, in the form of large lobes of fat-cells which spread through the intervals of the viscera in the general cavity of the body. It is interpenetrated and retained in place by numerous tracheæ.

THE CIRCULATORY SYSTEM. The vascular, or circulatory, system is not a closed sac as in the Worms and Vertebrates. The organs of circulation consist of a contractile, articulated dorsal vessel, or so-called "heart," which terminates in a cephalic aorta. The dorsal vessel receives the venous current through the lateral valvular openings and pumps the blood into its prolongation or cephalic aorta, whence it escapes, traversing the body in all directions, in regular currents, which do not have, however, vascular walls. "In this way, it penetrates the antennæ, the extremities, the wings, and the other appendages of the body, by arterial currents, and is returned by those of a venous nature. All the venous currents empty into two lateral ones, running towards the posterior extremity of the body, and which enter, through lateral orifices, the dorsal vessel." (Siebold.)

"The *blood* of the Insecta is usually a colorless liquid, though sometimes yellowish, but rarely red. In this liquid are suspended a few very small, oval, or spheroidal corpuscles, which are always colorless, have a granular aspect, and are sometimes nucleated.

"The *dorsal vessel*, which is constricted at regular intervals, is always situated on the median line of the abdomen, being attached to the dorsal wall of its segments by several triangular muscles whose apices point outwards. Its walls contain both longitudinal and transverse fibres, and, externally, are covered by a thin peritoneal tunic. Internally, it is lined by another very fine membrane, which, at the points of these constrictions, forms valvular folds, so that the organ is divided into as many chambers as there are constrictions. Each of these chambers has, at the anterior extremity on each side, a valvular orifice which can be inwardly closed. The returning

blood is accumulated about the heart and enters into it during the diastole of each of its chambers, through the lateral orifices (Fig. 46 *i*). It then passes, by the regularly successive

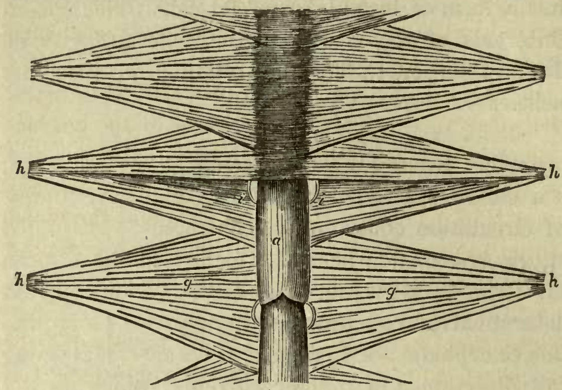


Fig. 46.


Fig. 47.

contractions of the heart, from behind forwards into the aorta, which is only a prolongation of the anterior chamber. This aorta consists of a simple, small vessel, situated on the dorsal surface of the thorax (Fig. 44 *e*, *f*), and extending even to the cephalic ganglion, where it either ends in an open extremity, or divides into several short branches which terminate in a like manner. The length of the dorsal vessel depends, in all the three states of insects, upon that of the abdomen. The number of its chambers is very variable, but is, most usually, eight.

"The blood, after leaving the aorta, traverses the body in currents which are also extravascular, and in this way bathes all the organs. The newly-prepared nutritive fluid passes through the walls of the digestive canal in which it is found, into the visceral cavity, and thence directly into the blood. Latterly, this extravascular circulation has been called in question, but its presence may be easily and directly observed

FIG. 46. Part of the dorsal vessel or heart of *Lucanus cervus*; *a*, the posterior chambers (the anterior chambers are covered by a part of the ligaments which hold the heart in place). *i*, the auriculo-ventricular openings; *g*, *g*, the lateral muscles fixed by the prolongations *h*, *h*, to the upper side of the abdomen.—*From Straus Durckheim.*

FIG. 47. Interior of the dorsal vessel; *a*, the inner walls with their circular fleshy fibres; *c*, the auriculo-ventricular opening; with its semilunar valve (*c*), in front of which is *d*, the interventricular valvule.—*From Straus Durckheim.*

with very many perfect Insecta and their larvæ. The vascular walls, supposed to have been seen at certain points, are, undoubtedly, the result of some error of observation or interpretation. This is also true of the pulsatile organs supposed to have been observed in the legs of many water-bugs, and which were thought to affect the circulation."

Blanchard and Agassiz believe in a "peritracheal circulation," and other observers agree that the course of the circulation is along the tracheæ, *i.e.* that the blood circulates in the space between the loose peritoneal envelope and the trachea itself. Professor H. J. Clark objects to this view that the blood disks are too large to pass through such an exceedingly minute space as the distance between the trachea and its enveloping, or peritoneal, wall.

Newport thinks that there are actual blood vessels distributed from the heart and "passing transversely across the dorsal surface of each segment in the pupa of *Sphinx*. If they be not vessels distributed *from* the heart, it is a somewhat curious circumstance that the whole of the blood should be first sent to the head of the insect, and the viscera of the abdominal region be nourished only by the returning blood, which has in part passed the round of the circulation."

Newport also describes in *Sphinx* the *supra-spinal*, or great ventral vessel which lies in the abdomen just over the nervous cord, and which is also found in the Scorpion and Centipede. He believes "this vessel to be the chief means of returning the blood from the middle and inferior portion of the body to the posterior extremity of the dorsal vessel or heart." He strongly suspects that anteriorly this great ventral vessel is connected with the aorta. The circulation of Insects, therefore, is probably as much a closed one as in the Myriapods, for he states that the "blood certainly flows in distinct vessels, at least in some parts of the body in perfect insects, and that vessels exist even in the larva." Observations on the vascular system are exceedingly difficult from the delicate structure of the vessels, and the subject needs renewed observations to settle these disputed points.

The blood is forced through the vessel into the body by regular pulsations. Herold counted thirty to forty in a minute in a

full-grown caterpillar; we have counted about sixty a minute in the recently hatched larva of *Diplax.* During excitement, the number of pulsations increases in rapidity. Newport found the pulsations in a bee, *Anthophora*, when quiet, to be eighty a minute; but when "the insects were quite lively, and had been exposed to the sun for an hour or two, the number of pulsations amounted to one hundred and forty."

He found that the *number* of pulsations decreased after each moult of the larva of *Sphinx ligustri*, but increased in *force;* when it was full grown and had ceased feeding it was thirty. "After it had passed into the pupa state the number fell to twenty-two, and afterwards to ten or twelve, and, during the period of hibernation, it almost entirely ceases; but in the perfect insect it rose from forty-one to fifty, and when excited by flight around the room it was from one hundred and ten to one hundred and thirty-nine."

Organs of Respiration. All insects breathe air, or, when they live in the water, respire, by means of branchiæ, the air mixed mechanically with water. Respiration is carried on by an intricate system of tubes (pulmonary tracheæ) which open by pores (spiracles or stigmata) in the sides of the body; or, as in aquatic insects, by branchiæ, or gill-like flattened expansions of the body-wall penetrated by tracheæ (branchial tracheæ).

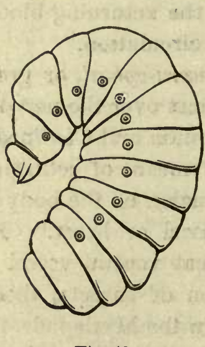


Fig. 48.

There are sometimes eleven spiracles, or breathing-holes (Fig. 48), on each side of the body; each consisting of an oval horny ring situated in the peritreme and closed by a valve, which guards the orifice (Fig. 49). Within this valve is a chamber closed within by another valve which covers the entrance into the tracheæ. The air-tube itself (Fig. 50) consists of "an external

Fig. 48. Larva of the Humble-bee just beginning to change to a pupa, showing eleven pairs of stigmata. In the adult bee, only the fourth pair is apparent, the remaining pairs being concealed from view, or in part aborted. In most insects there are usually only nine pairs of stigmata.—*Original.*

serous, and an internal mucous membrane, inclosing between them a spirally convoluted fibre, thus giving great strength and flexibility to the tube."

Nearly all the air enters through the thoracic and first abdominal spiracles, so that on pinching most insects on the thorax they can be easily deprived of breath and killed.

Fig. 49.

Fig. 50.

"In some aquatic larvæ such as those of *Dyticidæ*, *Eristalis* (Fig. 51, pupa), and *Ephydra*, and also in some perfect insects, as in *Nepa* and *Ranatra*, the parts supporting the stigmata are prolonged into slender tubes, through which the insect, on rising to the surface, breathes the atmospheric air.

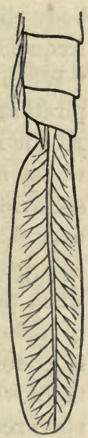


Fig. 52.

Agrion (Fig. 52) affords a good instance of branchiæ or gill-like expansions of the crust, or skin. It is supposed that these false gills, or branchiæ, "absorb the air from the water, and convey it by the minute ramifications of the tracheal vessels, with which they are abundantly supplied, and which terminate in single trunks, into the main tracheæ, to be distributed over the whole body, as in insects which live in the open atmosphere." (Newport.)

Fig. 51.

Of branchiæ there are three kinds. The first, as in the larvæ and pupæ of Gnats, consist of slender filaments arranged in tufts arising from a single stem. In the larva of *Gyrinus* and the aquatic caterpillar of a moth,

FIG. 49. Chamber leading into the trachea; *a, a*, external valve protecting the outer opening of the stigma, or breathing hole; *b, c, c*, inner and more complicated valve closing the entrance into the trachea (*l, k*); *m*, conical occlusor muscle closing the inner orifice.— *From Straus Durckheim.*

FIG. 50. Portion of a trachea divested of its peritoneal envelope. *a*, spirally convoluted fibre, closely wound around the trachea, as at *e*; *c*, origin of a secondary tracheal branch.— *From Straus Durckheim.*

FIG. 52. One of the three gill-like appendages to the abdomen of the larva and pupa of *Agrion* enlarged, consisting of a broad leaf-like expansion, permeated by tracheæ which take up by endosmosis the air contained in water.— *Original.*

Hydrocampa stratiolata, they form short stiff bristles placed along the side of the body. *Agrion* and *Ephemera*, in their larval stages, afford the second kind of branchiæ, and *Libellula* the third kind, or internal gill, situated in the colon. The Mosquito breathes both by branchiæ which form large club-shaped organs, and by lateral filaments.

In those insects that fly, most of the tracheæ are often dilated into *air-vesicles*, so that by filling and emptying them of air the insect can change its specific gravity. That their use is also to lighten the body is shown by their presence in the heavy mandibles and head of the male of *Lucanus cervus*. In the adult Humble-bee there are two very large vesicles at the base of the abdomen. These vesicles are not found in the larvæ, or in the adult forms of creeping insects.

The *act of respiration* consists in the alternate dilation and contraction of the abdominal segments, the air entering the body chiefly at the thoracic spiracles. As in the Vertebrates the frequency of the acts of breathing increases after exertion. "When an insect is preparing itself for flight, the act of respiration resembles that of birds under similar circumstances. At the moment of elevating its elytra and expanding its wings, which are, indeed, acts of respiration, the anterior pairs of spiracles are opened, and the air rushing into them is extended over the whole body, which, by the expansion of the air-bags, is enlarged in bulk, and rendered of less specific gravity; so that when the spiracles are closed at the instant the insect endeavors to make the first stroke with and raise itself upon its wings, it is enabled to rise in the air, and sustain a long and powerful flight with but little muscular exertion. In the pupa and larva state respiration is performed more equally by all the spiracles, and less especially by the thoracic ones."

During hibernation the act of breathing, like the circulation of the blood, almost entirely ceases, and the heat of the body is greatly lowered. Indeed Newport has shown that the *development of heat* in Insects, just as in Vertebrates, depends on the "quantity and activity of respiration, and the volume and velocity of the circulation." The Humble-bee, according to Newport, possesses the *voluntary power* of generating heat by breathing faster. He says, confirming Huber's observations,

"the manner in which the bee performs her incubatory office is by placing herself upon the cell of a nymph (pupa) that is soon to be developed, and then beginning to respire at first very gradually. In a short time the respirations become more and more frequent, until at length they are increased to one hundred and twenty, or one hundred and thirty per minute. The body of the insect soon becomes of a high temperature, and, on close inspection, is often found to be bathed with perspiration. When this is the case the temperature of the insect soon becomes reduced, and the insect leaves the cell, and another bee almost immediately takes her place. When respiration is performed less violently, and consequently less heat is evolved, the same bee will often continue on a cell for many hours in succession. This extreme amount of heat was evolved entirely by an act of the will in accelerating the respiratory efforts, a strong indication of the relation which subsists between the function of respiration and the development of animal heat."

Organs of Secretion. The urinary vessels, or what is equivalent to the kidneys of the higher animals, consist in Insects of several long tubes which empty by one or two common secretory ducts into the posterior or "pyloric" extremity of the stomach. There are also *odoriferous glands*, analogous to the cutaneous glands of vertebrates. The liquid poured out is usually offensive, and it is used as a means of defence. The Bees, Wasps, Gall-flies, etc., and Scorpions, have a poison-sac (Fig. 54*g*) developed in the tip of the abdomen. The bite of the Mosquito, the Horse-fly, and Bed-bug is thought by Newport to be due to the simple act of thrusting their lancet-like jaws through the skin, and it is not known that these and other insects which bite severely eject any poison into the wound. But in the spiders a minute drop of poison exudes from an orifice at the end of the mandibles, "which spreads over the whole wound at the instant it is inflicted." This poison is secreted by a gland lodged in the cephalo-thorax, and which is thought by Audouin to correspond in position to the salivary apparatus and the silk glands of the Winged Insects.

Organs of Generation. We have already described the external parts. The internal parts of the male insect consist,

of a duct, the *ductus ejaculatorius*, which opens into the external intromittent organ. This duct extends backwards, connecting with the *vesiculæ seminales*, which lead by the *vasa differentia* to the *testes* (Fig. 53). The latter are usually rounded glandular bodies, sometimes, as in *Melolontha* and *Lucanus*, numbering six on a side. These organs lie in the abdominal cavity, usually above and on each side of the alimentary canal.

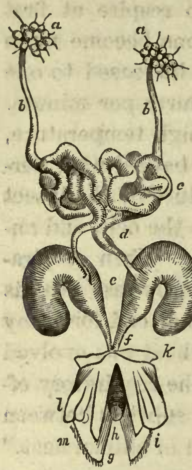


Fig. 53.

The sperm, or fertilizing fluid, contains very active spermatic particles which are developed in large cells in the testes, where they are united into bundles of various forms.

In the female, the internal reproductive organs (Fig. 54) are more simple than those of the other sex. The external opening of the female is situated at the end of the oviduct, that leads by two tubes to the ovary, which consists of two or more tubes (in the Queen Bee one hundred and sixty to one hundred and eighty) in which the ova are developed. On the upper side

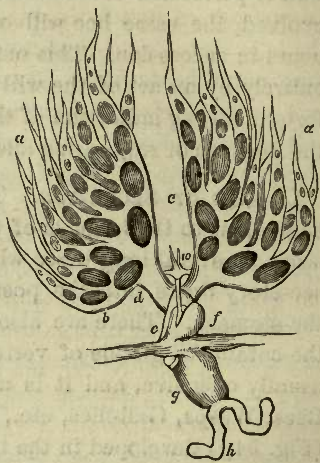


Fig. 54.

FIG. 53. Male organs of *Athalia centifoliæ*. *h*, the penis, or external portion, in which the *ductus ejaculatorius* (*f*) terminates, which extends backwards, and is connected with the *vesiculæ seminales* (*e*), and *vasa differentia* (*d*) which are connected with the *epididymis* (*b*), and the *testes* (*a*). *i* and *l*, two pairs of horny plates, surrounded by a horny ring (*k*). *i*, horny prehensile hooks attached to *k*. *m*, two elongated muscular parts inclosing the penis (*h*).—*From Newport.*

FIG. 54. Female organs of generation of *Athalia centifoliæ*. *a*, *b*, *c*, the eighteen ovarial tubes originating from each of the two oviducts (*e*), and containing the immature eggs; *f*, the spermatheca; *g*, poison-sac, the poison being secreted in the secretory vessels *h*. The poison flows through the oviduct into the sting and thence into the wound made by the sting. 10, the terminal ganglia of the nervous cord. —*From Newport.*

of the oviduct are from one to five appendages, the most important of which is the *spermatheca* (the others being sebaceous glands), which receives the fertilizing fluid of the male during sexual union, and in which, according to Darwin, the male element "is enabled to keep alive four or five years."

Insects bisexual. With the exception of the *Tardigrades*, which are doubtfully referred to the Mites (*Acarina*), there are no hermaphrodites among Insects, that is, there are no individuals having both male and female organs, and capable of self-impregnation. On the contrary, the sexes are distinct; Insects are bisexual.

Hermaphrodites, so-called. Cases not unfrequently occur in which from arrest of development of the embryo, the sexual organs are imperfectly developed, so as to present the appearance of being both male and female. "Siebold has investigated some hermaphrodite Honey-bees belonging to the Italian race, obtained from a Dzierzon hive at Constance. He found in many of them a combination of sexual characters, not only in the external parts, but also in the generative organs. The mixture of the external characters is manifested sometimes only in the anterior or posterior part of the body, sometimes in all parts of the body, or only in a few organs. Some specimens present male and worker characters on the two sides of the body. The development of the internal organs is singularly correlated with these peculiarities of external organization. The sting, with its vesicle and gland, is well developed in hermaphrodites with the abdomen of the worker; soft in those with the drone-abdomen. The seminal receptacle, when present, is empty. The ovaries contain no ova. In the hermaphrodites with the drone-abdomen, the male sexual organs are well developed, and the testes contain spermatozoids. Frequently with testicular and ovarian organs present on each side, the epididymis and copulatory apparatus are well developed, and an imperfect poison-apparatus exists. In these cases the tube contains spermatozoids, but there are no ova in the ovaries. The hermaphrodites are thrown out of the cell by the workers as soon as they emerge, and speedily perish. Siebold ascribes the production of these hermaphrodites to an imperfect fecundation of the ovum." (Zeitschrift für Wissenschaftliche Zoologie, 1864, p. 73. See Günther's Zoölogical Review for 1864.)

Mr. Dunning describes a specimen of *Fidonia piniaria*, "which was sexually a female, and the abdomen was apparently distended with eggs; the general color was midway between the colors of the ordinary male and female, but the size and markings were those of the male. (Transactions Entomological Society, London, Aug. 7, 1865.) Professor Westwood states that "he had an Orange-tip Butterfly (*Anthocharis cardamines*), which was female in every respect, except that on the tip of one fore-wing were about a dozen of the bright orange scales which characterize the male."

THE EGG. Professor H. J. Clark (Mind in Nature) defines an egg to be a globule surrounded by the vitelline membrane, or yelk-envelope, which is protected by the *chorion*, or egg-shell, consisting of "two kinds of fluid, *albumen* and *oil*, which are always situated at opposite sides or poles." "In the earliest stages of all eggs, these two poles shade off into each other," but in the perfectly developed egg the small, or albuminous pole, is surrounded by a membrane, and forms the Purkinjean (germinal) vesicle; and thirdly and last, the innermost of the three globules is developed. This last is the Wagnerian vesicle, or *germinal dot*. The oily matter forms the *yolk*. Thus formed, the egg is the *initial animal*. It becomes an animal after contact with the male germs (unless the product of organic reproduction), and the egg-shell or chorion is to be considered as a protection to the animal, and is thrown off when the embryo is hatched, just as the larva throws off its skin to transform into the pupa. So that the *egg-state* is equivalent to the larva state, and hence there are four stages in the life of an insect, *i. e.* the egg, the larva, the pupa, and the imago, or adult state.

The egg is not always laid as a perfect egg (Clark). It sometimes, as in the Ants, continues to grow after it is laid by the parent, like those of frogs, which, according to Clark, "Are laid before they can hardly be said to have become fully formed *as eggs*." Again, others are laid some time after the embryo has begun to form; and in some, such as *Melophagus* and *Braula*, the larva is fully formed before it is expelled from the oviduct.

Eggs are usually small in proportion to the size of the parent; but in many minute forms (*i.e. Pulex*, *Pediculus*, etc.) they are proportionately much larger. In shape eggs are either spherical or oblong. In some there are radiating appendages at one end, as in those of *Nepa* and *Ranatra*; or they are provided with a single stalk, as in *Chrysopa*, *Cynips*, and *Ophion*.

The eggs of most Hymenoptera, Diptera, and many Coleoptera are usually cylindrical; those of Lepidoptera are more generally spherical. The eggs of the Mosquito are laid in a boat-shaped mass, which floats on the surface of quiet pools, while those of the *Chrysopa*, or Lace-winged Fly (Fig. 55), are supported on long pedicels. They are almost invariably laid near or upon objects destined to be the food of the future larva. Thus the *Copris*, or "Tumble-bug," places its egg in a ball of dung which it rolls away to a secure place; the Flesh-fly oviposits on meat; and all vegetable-feeders lay their eggs on the food-plant where the larva, upon its exit from the egg, shall readily find an ample supply of food.


Fig. 55.

The posterior end of the egg is more often the fixed one, and it may thus be distinguished from the anterior pole. In the eggs of some Diptera and Orthoptera, the ventral side of the embryo, according to Gerstaecker, corresponds to the convex side of the egg, and the concave side of the latter corresponds to the dorsal region of the embryo.

The surface of the chorion, or egg-shell, which is dense and brittle, is often covered by a mosaic-work of more or less regular facets. In many small eggs the surface is only minutely granulated, or ornamented with ribs and furrows, as in those of many Butterflies.

The Micropyle. On the anterior end (though sometimes at both ends) of the egg is one or more pores of exceeding minuteness, through which the spermatozoa (more than one of which, according to Darwin, is requisite to fertilize an ovule) enter to fertilize the egg-contents. In some cases these micropyles are scattered over the whole surface of the egg. Fig. 56 *a* represents the micropyles of *Nepa cinerea*, consisting

of a whorl of long bristles. Those of *Locusta viridissima* (Fig. 56 *b*) slightly resemble toadstools. Fig. 56 *c* represents the anterior pole of the egg with the micropyles of *Pyrhocoris apterus*.—(*From Gerstaecker.*)

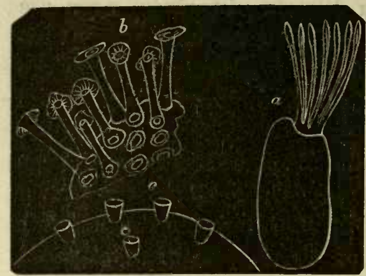


Fig. 56.

This contact of a male sperm-cell with the yolk is the fertilization of the egg. From this moment begins the life of the embryo. Fertilization of the female germ by means of the male sperm, through the congress of the sexes, is the rule with bisexual animals, but there are exceptions among insects. An embryo may start into being without the interposition of the male; to this mode of generation has been applied by Leuckart the term *Parthenogenesis.* Among certain species of insects there are some individuals which, by a sort of budding process, and without the aid of the male element, throw off summer broods, consisting of "asexual" individuals, which, as winter approaches, are succeeded by a brood of true males and females, the latter of which lay eggs. This phenomenon, called by Steenstrup "alternation of generations," has been observed among a comparatively few species, and the apparent design of such an anomalous mode of reproduction is to afford an immense number of individuals, thus providing for the continuance of the species. The individuals in whom this budding process takes place are called "asexual" because, though they may resemble the female sex outwardly, their sexual organs are only partially developed. This budding process is the same in kind with that observable in the Jelly-fish, which throw off by parthenogenesis, or alternations of generations, summer broods of immense extent, but in winter propagate by true eggs. Huxley has studied the development of Aphis by parthenogenesis, the anomalous nature of which has previously been discovered by Bonnet, Trembly, Lyonet, Degeer, Kyber, and others, and arrives at the following conclusions:

"1. Ova deposited by impregnated female *Aphides* in autumn are hatched in the spring.

2. From these ova viviparous, and, in the great majority of cases, apterous forms proceed.

3. The broods to which these give rise are either winged or apterous, or both.

4. The number of successive broods has no certain limit, but is, so far as we know at present, controlled only by temperature and the supply of food.

5. On the setting in of cold weather, or in some cases on the failure of nourishment, the weather being still warm, males and oviparous females are produced.

6. The males may be either winged or apterous.

7. So far as I am aware, there is no proof of the existence of any exception to the law that the oviparous female is apterous.

8. Viviparous *Aphides* may hybernate, and may co-exist with oviparous females of the same species." (Linnæan Transactions, xxii, p. 198.)

The origin of the viviparous, asexual, or *agamic* (from the Greek *a*, without; *game*, marriage) individual, as it may be more properly called, is, up to a certain stage, the same as that of the true egg, *i.e.* until the germ (*pseudovum*) of the former is detached from the false ovary (pseudovarium). "From this point onwards, however, the fate of the pseudovum is different from that of the ovum. The former begins at once to be converted into the germ; the latter accumulates yelk-substance, and changes but little. Both bodies acquire their membranous investment rather late; within it the pseudovum becomes a living larva, while the ovum is impregnated, laid, and remains in a state of rest for a longer or shorter period.

"Although, then, the pseudovum and the ovum of *Aphis* are exceedingly similar in structure for some time after they have passed out of the condition of indifferent tissue, it cannot be said that the sole difference between them is, that the one requires fecundation and the other not. When the ovum is of the size of a pseudovum which is about to develop into an embryo, and, therefore, long before fecundation, it manifests its inherent physiological distinctness by becoming, not an embryo, but an ovum. Up to this period the influence of fecundation has not been felt; and the production of ova, instead of

pseudova, must depend upon a something impressed upon the constitution of the parent before it was brought forth by its viviparous progenetrix." (Huxley.)

Siebold has also shown that the "ova of the Queen-bee produces females or males, according as they are fecundated or not. The fecundated ovum produces a queen or a neuter according to the food of the larva and the other conditions to which it is subjected; the unfecundated ovum produces a drone." This is analogous to the agamic reproduction of Aphis, and "demonstrates still more clearly the impossibility of drawing any absolute line of demarcation histologically between ova and buds."

This process of reproduction is not known in the Myriapods. It occurs among the mites (*Acarina*), and occurs in isolated genera of Hemiptera (*Aphis*, *Chermes*, *Lecanium*, and *Aspidiotus* according to Gerstaecker).

Among Lepidoptera the Silk-moth sometimes lays fertile eggs without previous sexual union. This very rarely happens, for M. Jourdain found that, out of about 58,000 eggs laid by unimpregnated silk-moths, many passed through their early embryonic stages, showing that they were capable of self-development, but only twenty-nine out of the whole number produced caterpillars. (Darwin.) Several other moths* have been found to lay fertile eggs without previous sexual union, and among Hymenoptera, *Nematus ventricosus*, *Cynips*, *Neuroterus*, perhaps *Apophyllus* (according to Gerstaecker), and *Cynips spongifica* (according to Walsh, Proceedings of

*We give a list from Gerstaecker (Bronn's Classen und Ordnungen des Thierreichs) of all the known cases of agamic reproduction in this suborder, with the number of times the phenomenon has been observed, and the names of the observers.

Sphinx ligustri, once (Treviranus).
Smerinthus populi, four times (Nordmann).
Smerinthus ocellatus, once (Johnston).
Euprepia caja, five times (Brown, etc.).
" *villica*, once (Stowell).
Telea Polyphemus, twice (Curtis).
Gastropacha pini, three times (Scopoli, etc).
Gastropacha quercifolia, once (Basler).
" *potatoria*, once (Burmeister).
Gastropacha quercus, once (Plieninger).
Liparis dispar, once (Carlier).
"*Egger moth*" (? *Liparis dispar*), (Tardy, Westwood).
Liparis ochropoda, once (Popoff).
Orgyia pudibunda, once (Werneburg).
Psyche apiformis, once (Rossi).
" *helix* (Siebold).
Solenobia lichenella (Siebold).
" *triquetrella* (Siebold).
Bombyx mori, several times.

The subject has been also discussed by Siebold in his work entitled, A true Parthenogenesis in Lepidoptera and Bees; by Owen, in his "Parthenogenesis," and by Sir J. Lubbock in the Philosophical Transactions, London, vol. 147, pt. 1.

the Entomological Society of Philadelphia). Parthenogenesis, or agamic reproduction, is, then, the result of a budding process, or cell-growth. This process is a common mode among the Radiates, the low Worms, and the Crustaceans. Metamorphosis is simply a series of marked stages, or periods, of growth; and hence growth, metamorphosis, and agamic reproduction are morphologically identical. All animals, therefore, as well as plants, grow by the *multiplication of cells.*

After hearing the surprising revelations of Bonnet, Réaumur, Owen, Burnett, and Huxley on the asexual mode of generation in the Aphis, we are called to notice still a new phase of reproduction. None of the observers just mentioned were accustomed to consider the virgin aphis as immature, but rather as a wingless *adult* Plant-louse. But Nicolas Wagner, Professor of Zoölogy at Kasan,* supported by able vouchers for the truth of his assertions, both in Russia and in Germany, who have repeated and thoroughly tested his observations, has observed an asexual reproduction in the *larva* of a Cecidomyian fly, *Miastor metraloas* Meinert, and Meinert has observed it in this species and the *Oligarces paradoxus* Meinert.

Says Dr. R. Leuckart, whose article† we have drawn largely upon in the present account, "This reproduction was said to commence in autumn, to continue through the winter and spring, giving origin, during the whole of this period, to a series of successive generations of larvæ, until, finally, in June, the last of them were developed into perfect and sexually mature animals. The flies, then, as usual, after copulation, lay eggs, and thus recommence the developmental cycle just described."

Professor Leuckart has observed these facts anew in the larvæ of a species of dipterous gall-fly, and which he believes distinct from the Russian species, found under the bark of a half dead apple-tree that was attacked by fungi. The young are developed within the body of the larva-like parent from a

* K. E. Von Baer, "Report on a New Asexual Mode of Reproduction observed by Professor Wagner in Kasan." Bull. Acad. St. Petersburg, 1863, pt. vi, p. 239. Also, Wagner in the Journal of the University of Kasan, 1861.

† On the Asexual Reproduction of Cecidomyia Larvæ. Annals and Magazine of Natural History, March, 1866. Translated from Zeitschrift für Wissenschaftliche Zoologie, Bd. xiv.

"germ-ball" essentially agreeing with the ovary, and the asexual larvæ begin life as egg-like bodies developed from this germ-ball, just as eggs are developed in the little tubes of which the ovary is an aggregation. Hence these worms *bud* out from the germ-stock, just as we have seen in the case of the Aphides. Leuckart and Wagner farther agree, that "the so-called chorion never being formed in either of them, the vitellus [yelk] remains without that envelope which has so remarkable and peculiar a development in the true egg of insects." . . . . "The processes of embryo-formation agree in all essential points with the ordinary phenomena of development in a fecundated egg, exactly as has been proved (by Huxley) to be the case in the *Aphides*." . . . . "The only difference consists in the germ-chambers of the Cecidomyide larvæ separating from the germ-stock, and moving about freely in the cavity of the body, whilst in the Aphides they remain permanently attached, and constitute an apparatus which, in its form and arrangement, reproduces the conditions of the female organs."

Thus we can neither pronounce these so-called *larvæ* to be larvæ so long as they produce young, neither are they actual males or females; they are what Leuckart calls *asexual* forms, which produce false-eggs (pseudova of Huxley, as restricted by Leuckart). This is paralleled by the asexual Aphides, and among Hymenoptera by the worker Ants, and worker, or, as they were formerly called, neuter Bees, the latter of which have been known to produce young without the interposition of the male; thus the two sexes, at least the females, are *dimorphic*, *i. e.* for certain exigencies of life they are specialized into two distinct forms, one (as in the asexual *Aphis*) to produce an unlimited number of young during the summer; the other and sexual, normal form to produce in the autumn a comparatively limited number of eggs.

Dimorphism is intimately connected with agamic reproduction. Thus the asexual Aphis, and the perfect female, may be called dimorphic forms. Or the perfect female may assume two forms, so much so as to be mistaken for two distinct species. Thus *Cynips quercus-spongifica* occurs in male and female broods in the spring, while the fall brood of females were

described as a separate species, *C. aciculata.* Mr. B. D. Walsh considers the two sets of females as dimorphic forms, and he thinks that *O. aciculata* lays eggs which produce *C. quercus-spongifica.*

Huber supposes there are two sizes of the three forms (*i. e.* male, female, and worker) of *Bombus*, one set being a little larger than the other.

Alfred Wallace has discovered that there are two forms of females of *Papilio Memnon* of the East Indies ; one is normal, having its wings tailed and resembles a closely allied species, *Papilio Coön*, which is not dimorphous, while the other is tailless, resembling its tailless male. *Papilio Pammon* has three sorts of females, and is hence "trimorphic." One of its forms predominates in Sumatra, and a second in Java, while a third, (described as *P. Romulus*) abounds in India and Ceylon. *P. Ormenus* is trimorphic, as Mr. Wallace obtained in the island of Waignion, "a third female quite distinct from either of the others, and in some degree intermediate between the ordinary male and female." Much the same thing occurs in the North American *P. Turnus.* *Papilio Glaucus* is now known to be a dimorphic form of the former butterfly, both having, according to Mr. Uhler, been bred from the same batch of eggs. The ordinary form of the female of *P. Turnus* occurs north of lat. 37°, while the dimorphic form, *P. Glaucus*, occurs south of 42°.

The male sex also presents dimorphic forms. Mr. Pascoe (Proceedings of the Entomological Society of London, 1862, p. 71) states that there are dimorphic forms of *Anthribidæ ;* that they occur in the male of *Stenocerus* and *Micoceros.* Six species of *Dytiscus* have two female forms, the most common having the elytra deeply sulcate, while in the rarer forms the elytra are smooth as in the male.

There is a tendency, we would observe, in the more abnormal of the two sexual forms, to revert to a lower type. Thus the agamic Aphis is more generally wingless, and the tailless female butterfly mimics the members of a lower genus, *Pieris.* The final cause of Dimorphism, like that of agamic reproduction, is the continuance of the species, and is, so far as yet known, an exceptional occurrence.

Mimetic forms. Many insects often resemble, in a remark-

able manner, those of other groups. They are called mimetic forms. Insects are related to each other by analogy and affinity. Thus the truly tailless species of *Papilio*, *i. e.* those where the tail is absent in both sexes, are related by affinity to *Pieris*, which has rounded hind wings. They also stand next to *Pieris* in the system of Nature. But there are, on the other hand, mimetic forms, which borrow the features of groups far above them in the natural system. Thus the *Sesia* resembles a Bee, *Bombylius* and *Laphria* resemble *Bombus;* the Syrphus flies are easily mistaken for Wasps. So in the second series of suborders of Insects, *Forficula* resembles the *Staphylinus; Termes* resembles the true Ant; *Psocus*, the *Aphis; Ascalaphus* resembles *Papilio; Mantispa* recalls the Orthopterous *Mantis*, and *Panorpa* reminds us of the *Tipulæ* (*Bittacus* being strikingly analogous to the Dipterous *Bittacomorpha*). Thus these lower, more variable groups of insects strive, as it were, to connect themselves by certain analogous, mimetic forms, with the more stable and higher groups.

Comprehensive types are mimetic forms which combine the characters of other and generally higher groups. Thus each Neuropterous family contains mimetic forms which ally them strongly with some one of the six other suborders of insects. The early fossil insects are remarkable for combining the characters of groups which appear ages after. The most remarkable comprehensive type is a Carboniferous insect, the *Eugereon Boeckingi* mentioned farther on.

HYBRIDITY. Hybrids are sometimes produced between different species, but though it is known that different genera unite sexually, we know of very few authentic instances of the production of hybrids therefrom. One is related by Mr. Midford, who exhibited at the March 4th (1861) meeting of the London Entomological Society, hybrids produced from a male *Phigalia pilosaria*, and a female *Nyssia hispidaria*. "The males resemble *N. hispidaria*, but in color have the lighter and greener tint and transparency of wing of *P. pilosaria*."

THE DEVELOPMENT OF INSECTS. Immediately after the fertilization of the egg, the first act in the organization of the

future embryo is the formation of the germinal layer, or *blastoderm* (from the Greek, meaning primitive skin). This layer is formed at the surface out of a surface-layer of larger, often nucleolated, cells which nearly encompass the yolk-mass. At one point there is a break in this cellular layer, and the yolk granules reach to the surface, so that it appears darker than the other parts of the egg. This cellular layer is soon resolved into the blastoderm, or germinal layer, which thickens and narrows, forming a longitudinal band. This is the first stage of the embryo, which lies as a thin layer of cells upon the outer surface of the yolk. Both ends of the body are alike, and we shall afterwards see that its back lies next to the centre of the egg, its future ventral side looking outwards. The embryo is thus bent on itself backwards.

In the next stage the blastoderm divides into a certain number of segments, or joints, which appear as indentations in the body of the embryo. The head can now be distinguished from the posterior end chiefly by its larger size, and both it and the tail are folded back upon the body of the embryo, the head especially being sunk backwards down into the yolk-mass.

In a succeeding stage, as we have observed in the embryo of *Diplax*, a Dragon-fly (Fig. 57), the head is partially sketched

Fig. 57.

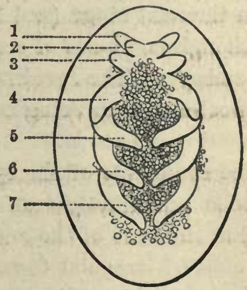


Fig. 58.

out, with the rudiments of the limbs and mouth-parts; and the sternites, or ventral walls, of the thorax and of the two basal rings of the head appear. The anterior part of the head, including the so-called "procephalic lobes" overhangs and con-

FIG. 57. Side view of embryo. The procephalic lobes are not shown. 1, antennæ; 2, mandibles; 3, maxillæ; 4, second maxillæ (labium); 5–7, legs. These numbers and letters are the same in all the figures from 57–60. The under-side (sternum) of six segments are indicated. FIG. 58. Ventral view of the same.

ceals the base of the antennæ. It is probable that more careful observation would have shown the end of the abdomen folded back upon the *dorsal* region, as usual at this period in the embryos of those insects whose embryology has been studied.

The antennæ, mandibles, and maxillæ form a group by themselves, while the second maxillæ (or labium) are very much larger and turned backwards, being temporarily grouped with the legs.

There are traces only of the two basal sterna of the abdomen. This indicates that the basal abdominal segments grow in succession from the base of the abdomen, the middle ones appearing last. The post-abdomen (Fig. 59 A) has probably been developed synchronous with the procephalic lobes, as it is in all insect and crustacean embryos yet observed. As stated by Zaddach, these two lobes in their development are exact equivalents; antero-posterior symmetry is very clearly demarked, the two ends of the body at first looking alike. But in this stage, after the two ends of the body have been evolved from the primitive cell-layer, development in the post-abdominal region is retarded, that of the head progressing with much greater rapidity.

In the next stage (not figured) the yolk is completely walled in, though no traces of segments appear on the back or side of the embryo. The revolution of the embryo has taken place; the post-abdomen being curved *beneath* the body, and the back presenting outwards.

The rudiments of the eyes appear as a darker, rounded mass of cells indistinctly seen through the yolk-granules, and situated at the base of the antennæ. They consist of a few epithelial cells of irregular form, the central one being the largest.

The second maxillæ are a little over twice the length of the first maxillæ and are grouped with the legs, being curved backwards. They are, however, now one-third shorter than the anterior legs. The second maxillary sternum is still visible.

The tip of the abdomen (or post-abdomen) consists of four segments, the terminal one being much the larger, and obscurely divided into two obtuse lobes.

The abdominal sternites are now well marked, and the ner-

vous cord is represented by eight or nine large oblong-square (seen sideways) ganglia, which lie contiguous to each other.

The formation of the eyes, the post-abdomen, the sternites, and median portion of the nervous cord seems nearly synchronous with the closing up of the dorsal walls of the body, though the division of the tegument into segments has not apparently taken place over the yolk-mass.

The succeeding stage (Fig. 59) is signalized by the appearance of the rudiments of the intestine, while the second maxillæ are directed more anteriorly.

Fig. 59.

In form the body is ovate-cylindrical, and there is a deep constriction separating the post-abdomen from the anterior part of the abdomen.

The terminal (eleventh) ring is immensely disproportioned to its size in the embryo just previous to hatching (see Fig. 61, where it forms a triangular piece situated between its appendages, the anal stylets). At a later period of this stage two more abdominal segments have been added, one to the end of the main body of the abdomen, and another to the post-abdomen. They have been apparently *interpolated* at the junction of the post-abdomen to the abdomen proper. Should this observation be proved to be correct, it may then be considered as a rule that, after reaching a certain number of segments, all additional ones are interpolated between the main body of the abdomen and its terminal segment or segments. This is the law of increase in the number of segments in Worms, and in Myriapods (*Iulus*, according to Newport's observations), in Arachnids (Claparede), and Crustacea (Rathke).

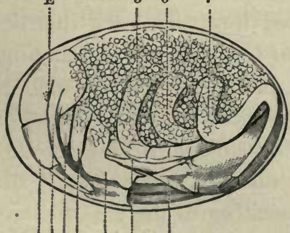


Fig. 60.

The next stage (Fig. 60), is characterized by the differentia-

FIG. 59. An embryo much farther advanced. C, clypeus; E, eye; A, bi-lobed extremity of the abdomen; I, the rudiments of the intestines.

tion of the head into the rudiments of the ophthalmic ring, and the supraclypeal piece, and clypeus, together with the approximation of the second pair of maxillæ, which, when united, form the labium, the extremities of which are now situated in the middle of the body.

The antennæ now extend to the middle of the labium, just passing beyond the extremities of the mandibles and maxillæ. The œsophagus can now be seen going from the mouth-opening situated just beneath the labium. It curves around just behind the eyes. There are at this period no appearances of movable blood-disks or of a dorsal vessel.

The abdomen is now pointed at the extremity and divided into the rudiments of the two anal stylets, which form large, acute tubercles. The yolk-mass is now almost entirely inclosed within the body walls, forming an oval mass.

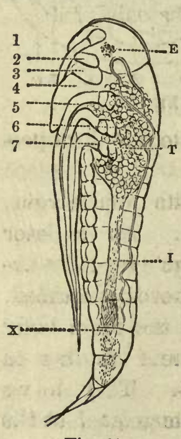


Fig. 61.

Another embryo, observed July 27th, had reached about the same stage of growth. The front of the head, including the antennary segment, is farther advanced than before. The entire head is divided into two very distinct regions; *i. e.* one *before* the mouth-opening (the *preoral* region, including the *ocellary*, or first and second segments; the *ophthalmic*, or third segment, and *antennary*, or fourth segment of the head); and the other *behind* the mouth (*postoral*, consisting of the *mandibular*, or fifth segment, the *first maxillary*, or sixth segment, and the *second maxillary*, or *labial*, being the seventh and last cephalic ring.

At a later period the embryo is quite fully formed, and is about ready to leave the egg. The three regions of the body are now distinct. The articulations of the tergum are present, the yolk-mass being completely inclosed by the tergal walls.

Fig. 61. The embryo taken from the egg, but nearly ready to hatch. T, the dotted line crosses the main trachea, going through the yolk-mass, now restricted to the thoracic region. At X, the tracheæ send off numerous branches around an enlargement of the intestine (colon), where the blood is aerated; better seen in fig. 62. The abdomen consists of eleven segments, the last being a minute triangular piece.

The body is so bent upon itself that the extremities of the second maxillæ just overlap the tip of the abdomen.

The two limbs of the labium are now placed side by side, with the prominent spinous appendage on the outer edges of the tip. These spines are the rudiments of the labial palpi.

The general form of the embryo at a still later period (Fig. 61), on being taken from the egg and straightened out, reminds us strikingly of the Thysanura, and, in these and other respects, tend to prove that the Poduræ and Lepismæ, and allied genera, are embryonic, degraded forms of Neuroptera, and should therefore be considered as a family of that suborder. Seen laterally, the body gradually tapers from the large head to the pointed extremity. The body is flattened from above downwards. At this stage the appendages are still closely appressed to the body.

Just before the exclusion of the embryo, the legs and mouth-parts stand out freer from the body. The labium, especially, assumes a position at nearly right angles to the body. The antennæ, mandibles, and maxillæ have taken on a more definite form, being like

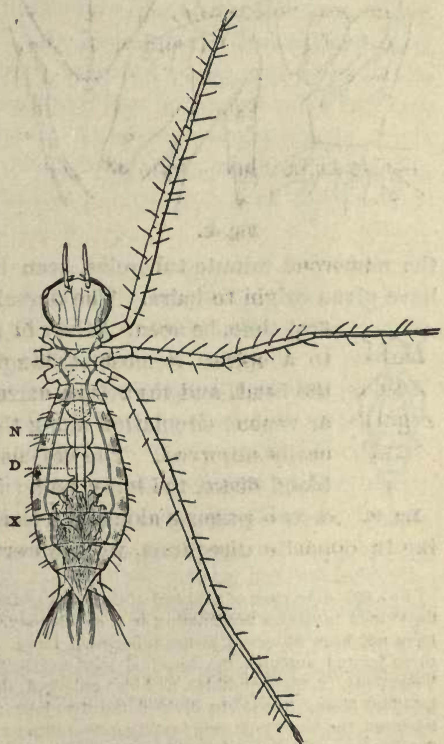


Fig. 62.

FIG. 62. The larva just hatched and swimming in the water. N, ventral cord or nervous ganglia; D, dorsal vessel, or "heart," divided into its chambers. The anal valves at the end of the abdomen, which open and shut during respiration, are represented as being open. Both of the dotted lines cross the tracheæ. X, network of the tracheæ, surrounding the cloaca.

that of the young larva, and stand out free from the body. The head is much smaller in proportion to the rest of the body, and bent more upon the breast.

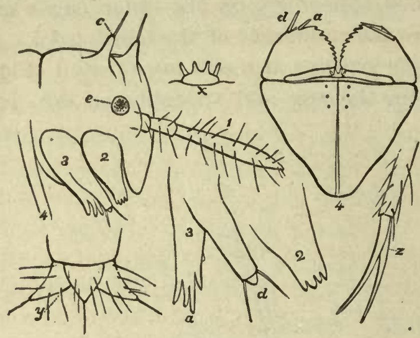


Fig. 63.

The Larva (Fig. 62) when hatched is about five hundredths of an inch in length. The head is now free and the antennæ stand out free from the front. The thorax has greatly diminished in size, while the abdomen has become wider, and the limbs very long; and the numerous minute tubercles, seen in the preceding stage, have given origin to hairs. The dorsal vessel can now, for the first time, be seen. When in motion, the resemblance to a spider is most striking. The flow of blood to the head, and the return currents through the lacunar or venous circulation along the side of the body were easily observed. The vessels were not crowded with blood disks, the latter being few in number, only one or two passing along at a time. Two currents, passing in opposite directions, were observed in the legs.


Fig. 64.

FIG. 63. Side view of the head of the larva of Diplax before the first moult. *c*, deciduous tubercles terminating in a slender style; their use is unknown; they have not been observed in the full-grown larva. *e*, the compound eyes. 1, the three jointed antennæ, the terminal joint nearly three times as long as the two basal ones. 2, the mandibles, and also enlarged, showing the cutting edge divided into four teeth. 3, maxillæ divided into two lobes: *d*, the outer and anterior lobe, 2-jointed, the basal joint terminating in two setæ; and *a*, the inner lobe concealed from view, in its natural position, by the outer lobe, *d*. 4, the base or pedicel of the second maxillæ, or labium, the expanded terminal portion being drawn separately; *d* and *a*, two movable stout styles representing, perhaps, the labial palpi; the lobe to which they are attached is multidentate, and adapted for seizing prey; on the right side the two styles are appressed to the lobe. *x* represents, perhaps, the ligula; but we have not yet studied its homologies carefully: this part is attached to a transversely linear piece soldered to the main part of the labium. *y*, the 11th abdominal ring, with its pair of conical anal styles. *z*, the last tarsal joint and pair of long slender claws.

FIG. 64. The pupa of Diplax, having rudimentary rings, in which the eyes are much larger, and the legs much shorter than in the recently hatched larva; introduced to be compared with the young larva. Figs. 57–64, *original*.

On review it will be seen how remarkable are the changes in form of the insect before it is hatched, and that all are the result of simple growth. We have seen that the two ends of the body are first formed, and that the under side of the body is formed before the back; that the belly is at first turned outwards, and afterwards the embryo reverses its position, the back presenting outwards. All the appendages are at first simple protrusions from the body-walls, and new segments are interpolated near the tip of the abdomen. These changes take place very rapidly, within a very few days, and some of the most important and earlier ones in a few hours. We can now better understand that the larva and pupa stages are the result of a similar mode of growth, though very marked from being in a different medium, the insect having to seek food and act as an independent being.

TRANSFORMATIONS OF THE INSECT. We have seen that during the growth of the embryo, the insect undergoes remarkable changes of form, the result of simple growth. The metamorphoses of the animal within the egg are no less marked than those which occur after it has hatched. It will also be seen that the larva and pupa stages are not always fixed, definite states, but only pauses in the development of the insect, concealing beneath the larva and pupa skins the most important changes of form.

The process of hatching. No other author has so carefully described the process of hatching as Newport, who observed it in the larva of Meloë. "When the embryo larva is ready for its change, the egg-shell becomes thinned and concave on that side which covers the ventral surface of the body, but is much enlarged, and is more convex on the dorsal, especially towards the head. The shell is then burst longitudinally along the middle of the thoracic segments, and the fissure is extended forwards to the head, which then, together with the thoracic segments, is partially forced through the opening, but is not at once entirely withdrawn. The antennæ, parts of the mouth, and legs are still inclosed within separate envelopes, and retain the larva in this covering in the shell. Efforts are then made to detach the posterior segments of the body, which

are gradually released, and with them the antennæ, palpi, and legs, and the larva removes itself entirely from the shell and membranes. In this process of evolution the young *Meloë* throws off two distinct coverings: first, the shell with its lining membrane, the analogue of the membrane in which, as I have elsewhere shown,* the young Myriapod is inclosed, and retained several days after the bursting of the ovum, and which represents in the Articulata, not the allantois, but apparently the amnion, of Vertebrata; next, the first, or fœtal deciduation of the tegument, analogous probably to the first change of skin in the Myriapod, after it has escaped from the amnion, and also to the first change which the young Arachnidan invariably undergoes a few days after it has left the egg, and before it can take food. This tegument, which, perhaps, may be analogous to the *vernix caseosa* of Vertebrata, thrown off at the instant of birth, is left by the young Meloë with the amnion in the shell; and its separation from the body, at this early period, seems necessary to fit the insect for the active life it has commenced." (Linn. Trans. xx. p. 306, etc.)

The larva state. The larva (Latin *larva*, a mask) was so-called because it was thought to mask the form of the perfect insect. The larvæ of Butterflies and Moths are called *caterpillars;* those of Beetles, *grubs;* and those of the two-winged Flies (Diptera) *maggots;* the larvæ of other groups have no distinctive common names.

As soon as it is hatched the larva feeds voraciously, as if in anticipation of the coming period of rest, the pupa state, for which stores of fat (the fatty bodies) are developed for the supply of fat globules out of which the tissues of the new body of the pupa and imago are to be formed.

Most larvæ moult, or change their skin, four or five times. In the inactive thin-skinned larvæ, such as those of Bees, Wasps, and Gall-flies, the moults are not apparent; as the larva increases in size it out-grows the old skin, which comes off in thin shreds. But in the active larvæ, such as caterpillars, grasshoppers, and grubs, from the rapid deposition of chitine in the outer layers of the skin, just before the change,

* Philosophical Transactions, Pt. 2, 1841, p. 111.

it becomes hard and dry, and too small for the growing insect, and is then cast off entire.

A series of bee-larvæ can be selected showing a graduation in size and form from the egg and recently hatched larva up to the full-grown larva. In the caterpillar and other active larvæ, there are usually four or five stages, each showing a sudden and marked increase in size. Newport states that the caterpillar of *Sphinx ligustri* moults six times, and at the last moult becomes a third larger than at any earlier period; the larva of *Arctia caja* moults from five to ten times.

A few days before the assumption of the pupa state, the larva becomes restless, stops eating, and deserts its food, and usually spins a silken cocoon, or makes one of earth, or chips, if a borer, and there prepares for the change to the pupa state.

During this semipupa period (lasting, in many insects, only for a day or several days, but in some Saw-flies through the winter) the skin of the pupa grows beneath that of the quiescent larva. While the worm-like larva exhibits no triregional distinctions, the muscles of the growing pupa contract and enlarge in certain parts so as to modify the larva form, until it gradually assumes the triregional form of the adult insect, with the differentiation of the body into a head, thorax, and abdomen.

In a series of careful studies, abundantly illustrated with excellent plates, Weismann has recently shown that Swammerdam's idea that the pupa and imago skins were in reality already concealed under that of the larva is partially founded in truth. Swammerdam states, "I can point out in the larva all the limbs of the future nymph, or *Culex*, concealed beneath the skin," and he also observed beneath the skin of the larvæ of bees just before pupating, the antennæ, mouth-parts, wings, and limbs of the adult. (Weismann.)

During its transformations the pupa skin is developed from the *hypodermis*, or inner layer of skin. This peals off, as it were, from the inner layer of the old larva skin, which soon dries and hardens, and is thrown off. Meanwhile the muscles of the body contract and change in form, thus causing the original segments of the larva to infold and contract at certain parts, gradually producing the pupa form. If, during this period, the

insect be examined at intervals, a series of slight changes of form may be seen, from the larva to the imago state. In some cases each change is accompanied by a moult, as in the "active" Ephemera, where Lubbock counted twenty moults.

As a general rule, then, it may be stated that the body of the larva is transformed into that of the imago; ring answering to ring, and limb to limb in both, the head of the one is homologous with that of the other, and the appendages of the larva are homologous with the appendages of the imago.

Weismann has shown that in the larva of the Meat-fly, *Musca vomitoria*, the thorax and head of the imago are developed from what he calls "imaginal disks." These disks are minute isolated portions of the hypodermis, which are formed in the embryo, before it leaves the egg, and are held in place within the body-cavity of the larva by being attached either to nerves or tracheæ, or both. After the outer layer of the larva skin dries and hardens, and forms the cask-shaped *puparium*, the use of which corresponds to the cocoon of moths, etc., these imaginal disks increase in size so as to form the tegument of the thorax and head. The abdomen of the Meat-fly, however, is formed by the direct conversion of the eight hinder segments of the body of the larva, into the corresponding segments of the imago.

Accompanying this change in the integument there is a destruction of all the larval system of organs; this is either total or effected by the gradual destruction of tissues. Now we see the use of the "fatty body;" this breaks up, setting free granular globules of fat, which, as we have seen in the embryo, produces by the multiplication of cells the new tissues of the pupa. Thus the larva-skin is cast aside, and also the softer organs within, but the formation of new tissues keeps even pace with the destruction of the old, and the insect preserves its identity throughout. The genital glands, however, are indicated even in the embryo, and are gradually developed throughout the growth of the insect, so that this *histolysis*, or destruction of tissues, is not wholly complete. The quiescent pupa-state of Musca is long-continued, and its vitality is latent, the acts of respiration and circulation being almost suspended. (Weismann.)

In the metamorphosis of *Corethra*, a Mosquito-like Fly, which is active both in the larva and pupa states, "the segments of the larva are converted directly into the corresponding segments of the body of the imago, the appendages of the head into the corresponding ones of the head of the imago; those of the thorax are produced after the last moult of the larva as *diverticula* of the hypodermis round a nerve or trachea, from the cellular envelope of which the formation of tissue in the interior of the appendages issues. The larval muscles of the abdominal segments are transferred unchanged into the imago; the thoracic muscles peculiar to the imago, as also some additional abdominal muscles, are developed in the last larval periods from indifferent cellular cords which are indicated even in the egg. The genital glands date back to the embryo, and are gradually developed; all the other systems of organs pass with little or no alteration into the imago. Fatty body none or inconsiderable. Pupa-state short and active." (Weismann.)

As the two types are most clearly discriminated by the presence or absence of true imaginal disks, Weismann suggests that those insects which undergo a marked metamorphosis might be divided into *Insecta discota* (or Insects with imaginal disks), and those without, into *Insecta adiscota*.

The metamorphosis of *Corethra* may prove to be a type of that of all insects which are active in their preparatory stages; and that of *Musca* typical of all those that are quiescent in the pupa-state, at least the Lepidoptera and those Diptera which have a coarctate* pupa, together with the Coleoptera and those Neuroptera in which the metamorphosis is complete, as *Phryganea*, *Hemerobius*, etc.

The transformations of the Humble-bee are easily observed by taking a nest after the first brood have matured, when we shall find individuals in all stages of development from the larva to the imago state. The figures below show four stages, but in reality there is every gradation between these stages.

* The larvæ of some of the higher Diptera spin a slight cocoon, while the true flies, such as the Muscidæ and Syrphidæ, etc., change to pupæ within the larva skin which contracts into a cylindrical "puparium" corresponding in use to the cocoon; such pupæ are called "coarctate."

Fig. 64 shows what we may call the semipupa, concealed by the larval skin. There are eleven pairs of stigmata, three thoracic and eight abdominal. The head of the semi-pupa lies under the head (*a*) and prothoracic ring (*b*). The basal ring of the abdomen (*c*), or fourth ring from the head, is unchanged in form. This figure also will suffice to represent

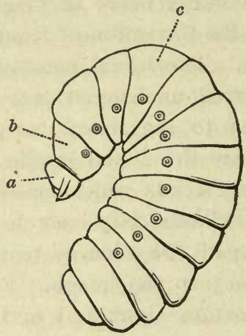


Fig. 64.

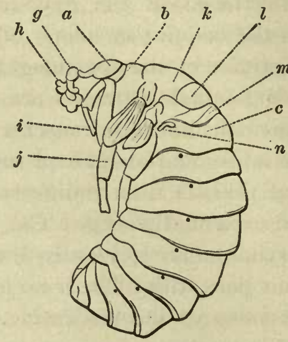


Fig. 65.

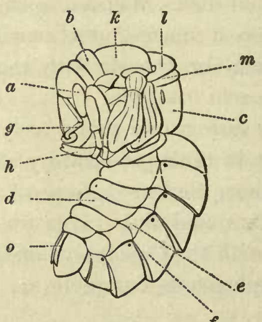


Fig. 66.

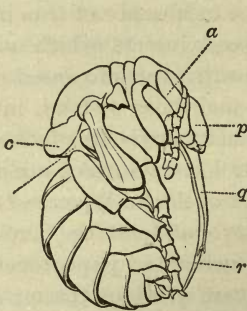


Fig. 67.

the larva, though a little more produced anteriorly than in its natural form.

In another stage (Fig. 65) of the semi-pupa, the larval skin is entirely sloughed off, the two pairs of wing-pads lying parallel, and very equal in size, like the wings of Neuroptera. The thoraco-abdominal ring, or *propodeum* (*c*), is distinguished by its oblong spiracle (*n*), essentially differing from those on the abdomen. At this point the body contracts, but the head

and thorax together are yet, as still more in the previous stage, much smaller than in the pupa, and there is still a continuous curve from the tip of the abdomen to the head. (*g*, antenna; *h*, lingua, maxillæ, and palpi; *i*, fore-legs; *j*, middle legs; *k*, meso-scutum; *l*, meso-scutellum; *n*, spiracle of the propodeum.)

In a succeeding stage (Fig. 66) of the semi-pupa, the head and thorax together nearly equal in size the abdomen, and the propodeum (*c*) has become entirely transferred to the thorax. The head has become greatly enlarged; the rings are very unequal, the hinder pair are much smaller, and overlaid by the anterior pair; the three terminal pair of abdominal rings, so large in Fig. 65, have been absorbed, and partially inclosed in the cavity of the abdomen; and there has been a farther differentiation of the ring into the sternite (*d*), pleurite (*e*), and tergite (*f*). (*a*, eye; *h*, lingua; *o*, ovipositor, two outer rhabdites exposed to view.) The abdominal spiracles in Figs. 65 and 66, are represented by a row of dots. In the pupa they are concealed by the tergites, which overlap the sternites.

Fig. 67 represents the pupa state, where the body has become much shorter, and the appendages of the head and thorax greatly differentiated; the external genital organs are wholly retracted within the cavity of the abdomen; the head is freer from the body, and the whole bulk of the head and thorax together, including the appendages, greater than that of the abdomen. These changes of form, assumed by the insect in its passage from the larva to the pupa state, are nearly as striking as the so-called "hypermetamorphosis" of *Meloë* and *Sitaris* described by Newport and Fabre. (*l*, mesoscutellum; *p*, clypeus; *q*, maxillæ with the palpi; *r*, lingua.)

We have also observed similar changes in the semi-pupa of a Tineid larva, which we found in the mud-cells of *Odynerus albophaleratus*. There were over a dozen specimens in different stages of growth from the larva to the pupa, which were but partially paralyzed by the well-directed sting of the intelligent wasp, so that some continued to transform into perfect pupæ.

The following changes were noticed: the larva straightened out, and became a little shorter, the prothoracic ring remaining the same; the head of the pupa being beneath it; the meso-

thoracic ring enlarged, swelling and rounding above and on the sides, and with this increase in size drawing the meta-thorax forwards. The first visible portion of the pupa beneath is the mesothorax. The thoracic legs of the larva are now constricted at their base, and have become useless.

In the next stage, the most important change noticed is in the metathorax, which now becomes broadly heart-shaped. In a succeeding stage, the whole thorax bulges out, and is much larger and clearly distinguished from the head and abdomen. The prothorax of the larva disappears, and that of the pupa takes its place. The occiput of the pupa, just before the larva-skin is thrown off, can be distinctly seen under the larval occiput, pushing aside each half of the latter.

In the last stage of *Bombus* just before the imago leaves its cell, the body and limbs are surrounded by a thin pellicle. This pellicle also envelops the moth, just before it leaves the pupal state, and is cast off when it moults the pupa-skin. This is probably identical with the skin cast by the active subimago of *Ephemera*, soon after it has taken its flight. Westwood also considers this subimago skin identical with that covering the bodies of coarctate Diptera, as in *Eristalis*.

Newport states, that when the imago of *Sphinx* is about to cast off the pupa-skin the abdominal segments are elongated beyond their original extent, this being the first part of the insect that is entirely freed from its attachment within the pupa-case. After this the thorax slits down, and the body is drawn out of the rent. In the Butterfly the wings mature in a few moments, but those of *Sphinx* being thicker, require two or three hours.

Newport (Philosophical Transactions, London, 1832 and 1834) has detailed with great minuteness the internal changes of *Sphinx ligustri* while transforming. The most marked changes are in the nervous and digestive systems.

Several anomalous modes of metamorphosis have been observed, one in Diptera and the other in *Sitaris* and *Meloë*. The development of the latter insect will be noticed beyond.

Sir John Lubbock has described the singular metamorphosis of *Lonchoptera*, which he considers to be allied to *Sargus*, though the adult stages differ greatly. The larvæ are oblong

ovate, flattened, with four long setæ in front and two behind, with the sides of the body emarginate and spinulated. They were found under logs. "When the larva is full grown, it detaches itself from the skin, which retains its form, and within which the insect changes into a white opaque fleshy grub consisting apparently of thirteen segments which gradually diminish in size from one end to the other. There are no limb-cases. According to analogy the pupa should be 'incomplete;' it is probable, therefore, that the legs and wings make their appearance at a later stage. If this be so the perfect form is only attained after passing through three well-marked stages. I regret, however, that the specimens at my disposal did not enable me to decide this point." (Trans. Ent. Soc. London, Third Ser. i, 1862.)

Haliday states that *Thrips* goes through a *propupa* and pupa stage. There are five well-defined stages in the Homopterous *Typhlocyba*, and more than three in *Aphis*. Yersin has noticed several stages in the development of *Gryllus campestris*, and the genus *Psocus* has four such stages.

The duration of the different stages vary with the changes of the seasons. Cold and damp weather retards the process of transformation. Réaumur kept the pupa of a Butterfly two years in an ice-house before, on being removed to a warm place, it changed to a butterfly. Chrysalids survive great alternations of heat and cold; they may be frozen stiff on ice, and then, on being gradually exposed to the heat, thaw out and finish their transformations.

Retrograde Development. There are certain degradational forms among the lowest members of each group of Insects which imitate the group beneath them. The *Tardigrades* (which are considered by some authors to be allied to the Mites) are mimicked by the low parasitic worm-like *Demodex folliculorum;* the low Neuroptera, such as *Lepisma*, imitate the Myriapoda; and the wingless Lice remind us of the larvæ of the Neuropterous *Hemerobius*.

Among the Coleoptera, the history of *Stylops* affords a striking example. The active six-footed larva is transformed into the strange bag-like female which takes on the form of a cylindrical sac, the head and thorax being consolidated into a

minute flattened portion. The process of degradation here seems carried out to its farthest limit.

Thus the degraded forms of the lower series of Hexapods take on a Myriapod aspect. In the more highly cephalized Diptera, Lepidoptera, and Hymenoptera the degraded forms are modelled on a higher articulate type. The idea of a division into three regions is involved. Thus the wingless forms of Flies, such as the Bird-louse, *Nirmus;* the Bat-tick, *Nycteribia;* the Bee-louse, *Braula;* and *Chionea* resemble strikingly the biregional Arachnids.

In the wingless female of *Orgyia* and the Canker-worm moth, the head is free, but the thorax is merged into the abdomen. The resemblance to the lower insects is less striking. The worker ants and wingless Ichneumons, *Pezomachus*, still more strictly adhere to the type of their suborder, and in them the triregional form of the body persists. Among the first of the examples here cited we have seen the workings of a law, by which most degraded forms of insects (and this law is exerted with greater force in Crustacea) tend to revert to the worm-like, or, as we may call it, the *archetypal*, form of all Articulata.

We have seen that many winged forms mimic the groups above them, whereas the wingless degraded species revert to a worm-like form. In either case, the progress is towards a higher or a lower form. The latter is the more exceptional, as the evolution and growth of all animals is upwards towards a more specialized, differentiated form.

The Imago. After completing its transformations the adult insect immediately seeks to provide for the propagation and continuance of the species. The sexes meet, and, soon after, the male, now no longer of use in the insect economy, perishes. The female hastens to lay her eggs either in, upon, or near what is to be the food of the young, and then dies. This period generally occurs in the summer and autumn, and during the winter the species is mostly represented by the egg alone. Rarely does the adult insect hibernate, but in many species the pupa hibernates to disclose the adult in early summer. The larva seldom, as such, lives through the winter.

Réaumur kept a virgin butterfly for two years in his hot-house. From this it would seem that the duration of the life

of an insect may be in this way greatly prolonged. Most insects live one year. Hatching from the egg in early summer, they pass through the larva state, and in the autumn become pupæ, to appear as imagos for a few days or weeks in the succeeding summer. Many Lepidoptera are double-brooded, and some have even three broods, while the parasitic insects such as Lice and Fleas, and many Flies, keep up a constant succession of broods. Warmth, Mr. R. C. R. Jordan remarks in the Entomologists' Monthly Magazine, has much to do with rapidity of development, as insects may be forced artificially into having a second brood during the same season. Some Coleoptera, such as the Lamellicorns, are supposed to live three years in the larva state, the whole time of life being four years. The Cockchafer (*Melolontha*) of Europe is three years in arriving at the perfect state, and the habits of the Goldsmith Beetle (*Cotalpa lanigera*), according to Rev. Samuel Lockwood (American Naturalist, vol. 2, p. 186), and of the June Beetle, and allied genera, are probably the same.

GEOGRAPHICAL DISTRIBUTION. The *insect-fauna* of a country comprises all the insects found within its limits. The Polar, Temperate, and Tropical zones each have their distinct insect-fauna, and each continent is inhabited by a distinct assemblage of insects. It is also a curious fact that the insect-fauna of the east coast of America resembles, or has many analogues in, that of the Eastern hemisphere, and the west coast of one repeats the characteristics of the west coast of the other. Thus some California insects are either the same species or analogues (*i.e.* representative species) of European ones, and the Atlantic coast affords forms of which the analogues are found in Eastern Asia and in India. This is correlated with the climatic features which are repeated on alternate sides of the two hemispheres.

The limits of these faunæ are determined by temperature and natural boundaries, *i.e.* the ocean and mountain ranges. Thus the insect-fauna of the polar regions is much the same in Europe, Asia, and North America; certain widely spread polar species being common to all three of these continents.

When we ascend high mountains situated in the temperate

zone, whose summits nearly reach the snow-line, we find a few insects which are the same or very similar to those of the polar regions; such an assemblage is called an Alpine fauna.

The insect-fauna of each great continent may be divided into an *Arctic*, or polar, a *Temperate*, and a *Tropical* fauna, and an *Alpine* fauna if there are mountains in the warm latitudes which reach near the snow-line. Mountain barriers, inland seas, deserts, and peculiarities in the flora (or collection of plants peculiar to a certain district), are boundaries of secondary importance in limiting the distribution of species.

On the other hand insects are diffused by winds, rivers, oceanic currents, and the agency of man. By the latter important means certain insects become cosmopolitan. Certain injurious insects become suddenly abundant in newly cultivated tracts. The balance of nature seems to be disturbed, and insects multiplying rapidly in newly settled portions of the country, become terrible pests. In the course of time, however, they seem to decrease in numbers and moderate their attacks.

Insect-faunæ are not limited by arbitrary boundaries, but fade into each other by insensible gradations corresponding in a general way to the changes of the temperature of different portions of the district they inhabit.

The subject of the geographical distribution of insects, of which we have as yet but given the rudiments, may be studied to great advantage in North America. The Arctic insect-fauna comprises Greenland, the arctic American Archipelago, and the northern shores of the continent beyond the limit of trees. A large proportion of the insects found in this region occur in arctic Europe and arctic Asia, and are hence called circumpolar, while other species are indigenous to each country. Again, the arctic fauna of Labrador and Hudson's Bay differs from that of the arctic portions of the region about Behring's Straits, certain species characterizing one side of the continent being replaced by representative species which inhabit the opposite side.

The Alpine fauna of the White Mountains consists, besides a very few peculiar to them, of circumpolar species, which are now only found in Labrador and Greenland, and which are

supposed to be relics of a glacial fauna which formerly inhabited the northern part of the temperate zone, and in former times followed the retreat of a glacial, or arctic climate from the low-lands to the Alpine summits. These patches, or outliers, of an Arctic fauna, containing however a preponderance of *subarctic* forms, also occur in the colder parts of New England.

The subarctic fauna is spread over British North America, stretching north-westerly from the interior of Labrador and the northern shores of the St. Lawrence, following the course of the isothermal lines which run in that direction, and north of which no cereals grow. There are subarctic forms which inhabit the shores of the Bay of Fundy, especially about Eastport, Maine, where the fogs and cold arctic marine currents lower the climate.

Dr. J. L. Leconte, in a paper on the Coleoptera of Kansas and Eastern New Mexico (Smithsonian Contributions to Knowledge), thus subdivides the Coleopterous fauna of the United States, and gives a useful map to which the reader is referred.

"The whole region of the United States is divided by meridional, or nearly meridional lines into three, or perhaps four, great zoölogical districts, distinguished each by numerous peculiar genera and species, which, with but few exceptions, do not extend into the contiguous districts. The eastern one of these extends from the Atlantic Ocean to the arid prairies on the west of Iowa, Missouri, and Arkansas, thus embracing (for convenience merely) a narrow strip near the sea-coast of Texas. This narrow strip, however, belongs more properly to the eastern province of the tropical zoölogical district of Mexico.

"The central district extends from the western limit of the eastern district, perhaps to the mass of the Sierra Nevada of California, including Kansas, Nebraska, Utah, New Mexico, Arizona, and Texas. Except Arizona, the entomological fauna of the portion of this district west of the Rocky Mountains, and in fact that of the mountain region proper, is *entirely* unknown; and it is very probable that the region does in reality constitute two districts bounded by the Rocky Mountains, and the southern continuation thereof.

"The western district is the maritime slope of the continent to the Pacific, and thus includes California, Oregon, and Washington Territories.

"These great districts are divided into a number of provinces, of unequal size, and which are limited by changes in climate, and therefore sometimes distinctly, sometimes vaguely defined."

"The method of distribution of species in the Atlantic and Pacific districts, as already observed by me in various memoirs, is entirely different. In the Atlantic district, a large number of species are distributed over a large extent of country; many species are of rare occurrence, and in passing over a distance of several hundred miles, but small variation will be found in the species obtained. In the Pacific district, a small number of species are confined to a small region of country; most species occur in considerable numbers, and in travelling even one hundred miles, it is found that the most abundant species are replaced by others, in many instances very similar to them; these small centres of distribution can be limited only after careful collections have been made at a great number of localities, and it is to be hoped that this very interesting and important subject of investigation may soon receive proper attention from the lovers of science of our Pacific shores.

"In the Central district, consisting, as it does to a very large extent, of deserts, the distribution seems to be of a moderate number of species over a large extent of country, with a considerable admixture of local species; such at least seems to be the result of observations in Kansas, Upper Texas, and Arizona."

There are a very few species which range from New England to Brazil, and fewer still (*Xyleutes robiniæ*, according to Boisduval, is found in California) range from New England to California. *Junonia cœnia*, according to authors, is found both in the Southern States and California, and *Pyrrharctia isabella* of the Eastern States would be easily confounded with *P. Californica*.

Variation. Islands afford more variable forms than continents; the Madeiran insects and those of Great Britain vary more than the same species found on the continent of Europe.

A species spread through two zones of temperature also varies; many European species, according to McLachlan, becoming "melanized" in going northward, while others become paler. Such varieties have been described as different species.

Mr. Alfred Wallace finds that the most constant forms of species are those the most limited in their geographical range as to a particular island, while those species, which range over a large part of the Malayan Archipelago, vary very considerably. It is a general rule throughout the animal and vegetable world, that the most widely spread species are those capable of withstanding the greatest climatic changes, and adapting themselves to the greatest diversities of topography.

While the most widely distributed species are thought to be the most variable, Mr. Scudder finds in the genus *Chionobas* that *C. semidea*, restricted to the summit of Mt. Washington varies almost as much as *C. Oeno*, which is circumpolar, being found both in Labrador and Northern Europe.

Mr. Wallace (Transactions of the Linnæan Society, xxv, 1865, p. 14) mentions the following facts "as showing the special influence of locality in giving a peculiar *facies* to the several disconnected species that inhabit it."

"On examining the closely allied species, local forms, and varieties distributed over the Indian and Malayan regions, I find that larger or smaller districts, or even single islands, give a special character to the majority of their Papilionidæ. For instance: 1. The species of the Indian region (Sumatra, Java, and Borneo) are almost invariably smaller than the allied species inhabiting the Celebes and Moluccas; 2. The species of New Guinea and Australia are also, though in a less degree, smaller than the nearest species or varieties of the Moluccas; 3. In the Moluccas themselves the species of Amboyna are largest; 4. The species of Celebes equal or even surpass in size those of Amboyna; 5. The species and varieties of Celebes possess a striking character in the form of the anterior wings, differing from that of the allied species and varieties of all the surrounding islands; 6. Tailed species in India or the Indian region become tailless as they spread eastward through the archipelago."

Variety breeding. Varieties may be produced artificially; thus negro varieties of insects may be raised "from parents

more or less tainted with melanism, and according to Knaggs, there is a "frequent recurrence of individuals wanting a hind wing, which may be noticed even at large in *Macaria notata.*" "Few species are liable to the same extent of variation, and many apparently to none at all." Certain species vary "according as they may have reproduced, generation after generation, on a chalky, peaty, gravelly, or other soil." Food also exerts an influence in inducing variation, according as caterpillars of the same species feed on different plants; this occurs most commonly in the Micro-lepidoptera. (Knaggs, in the Entomologist's Monthly Magazine, London.)

Introduced species of insects, like those of plants, often thrive more vigorously than the native forms. This is instanced by native insects which abound in unusual numbers in newly cleared districts where the former presence of forests and their natural foes kept them under. The Potato-beetle, Canker-worm, and *Clisiocampa* must have lived formerly in moderate numbers on our native plants, where now countless hosts affect our introduced plants. Among species introduced from a foreign country we have only to instance the Hessian Fly, the Wheat-midge, the Coddling-moth, the Clothes-moth, the Apple Bark-louse, and the Grain-weevil. Mr. W. T. Brigham informs us that some of the most abundant insects in the Hawaiian Islands are introduced species carried by vessels from Europe. *Vanessa Antiopa*, *Pyrameis cardui*, and *P. Atalanta*, so abundant in this country, are supposed to be introduced butterflies. *Aphodius fimetarius*, found by us living in dung on Mt. Washington, is one of our most common beetles, and the Asparagus-beetle, introduced from Europe a few years since, is common in gardens in Eastern New York, while Mr. Walsh has recorded the appearance of the European Gooseberry Saw-Fly, which ravages the Gooseberry and Currant. *Pieris rapæ*, the Cabbage-butterfly, introduced from Europe into Quebec about 1859, soon became abundant within a circle of forty miles radius about that city, and has even spread into Maine and Vermont along the railroads leading from Quebec.

Insect Years. There are insect years as well as "apple years," seasons when insects most abound. Every collector knows that there are certain years when a particular species of

insect is unusually common. The Army-worm, *Leucania unipuncta*, swarms in countless numbers in a summer following a dry and warm spring. After a cold and rainy spring, insects are less abundant. Mr. F. Smith remarks that in England the summer and autumn of 1860 were unusually wet, which disabled the bees, wasps, and fossorial hymenoptera generally, in building their nests. We know how ants are hindered from building their nests by rain, and in a very rainy season numbers probably die. A succession of rainy seasons caused the Andrenæ, or Spring bees, to disappear from the vicinity of London. While a severe winter, if the cold be continuous, is not injurious to insects, mild periods in winter, when it is warm enough to rouse them from torpidity, are as fatal to insects as to vegetation, should severe cold immediately follow.

Geological Distribution. The geological distribution of insects corresponds generally with that of other animals, though insect-remains are few in number, owing naturally to the difficulty with which their fragile forms are preserved in the rocks. Professor C. F. Hartt has discovered near St. John, New Brunswick, the oldest insect-remains in the world. They occur in some plant-beds of the Upper Devonian formation, and consist of six species of Neuroptera. Mr. Scudder, who has referred to them in vol. 1 of the American Naturalist, states that with the exception of one or two Ephemeridæ, or May-flies, they mostly represent families which are now extinct. He describes a gigantic May-fly, *Platephemera antiqua* (Pl. 1, fig. 3); *Lithentomum Harttii* (Pl. 1, fig. 5); *Homothetus fossilis* (Pl. 1, fig. 7); and *Xenoneura antiquorum* which is supposed to bear a stridulating organ like that of the Grasshoppers, so that he "is inclined to believe there were chirping Neuroptera in those days."

Ascending to the Carboniferous rocks, insect-remains appear more abundant. At Morris, Illinois, have been collected some remarkable forms. Among them are *Miamia Bronsonii* Dana (Pl. 1, fig. 1), allied to the White Ants and *Hemeristia occidentalis* Dana, allied to *Hemerobius* and *Chrysopa;* with these occurred remains at first supposed by Prof. Meek to be those of a caterpillar (Fig. 68), but now thought to belong to some worm.

In the Coal-beds of New Brunswick and Nova Scotia, Dr. Dawson, Mr. Barnes, and Professor O. C. Marsh have discovered several interesting Neuropterous and Orthopterous insects; among them a Cockroach, *Archimulacris Acadica* (Pl. 1,* fig. 2). In Europe, Carboniferous insects have been discovered at Wettin, Saarbrück, etc.

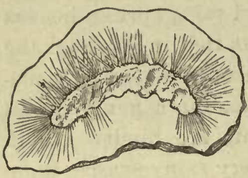


Fig. 68.

The insects from these two formations show a tendency to assume gigantic and strange shapes. They are also *comprehensive types*, combining the characters of different families and even different suborders. The most remarkable instance is the *Eugereon Boeckingii* Dohrn, from the Coal Formation of Germany. It has been referred by Dr. Hagen, with some doubt, to the Hemiptera, from its long immense rostrum into which all the mouth-parts are produced, the labium ensheathing them as usual in the Hemiptera. Its fore-legs are large and raptorial; but the filiform many-jointed antennæ, and the net-veined wings are Neuropterous characters. Hence Dohrn considers it as a comprehensive type uniting

* EXPLANATION OF PLATE 1.

Fig. 1. *Miamia Bronsonii.* A Neuropterous insect found in iron-stone concretions in the Carboniferous beds at Morris, Illinois. The figure is magnified one-third, and has all its parts restored; the dotted lines indicate the parts not existing on the stone. Reduced from a figure in the Memoirs of the Boston Society of Natural History, Vol. I.

Fig. 2. *Archimulacris Acadica.* Wing of a Cockroach observed by Mr. Barnes in the coal-formation of Nova Scotia.

Fig. 3. *Platephemera antiqua.* A gigantic May-fly obtained by Mr. Hartt in the Devonian rocks of New Brunswick.

Fig. 4. *Xylobius sigillariæ.* The Myriapod (or Gally-worm) found in the coal-formation of Nova Scotia, by J. W. Dawson. Copied from a figure in Dr. Dawson's Air-breathers of the Coal-period. Magnified.

Fig. 5. *Lithentomum Hartii.* A Neuropterous insect, the specimen first discovered by Mr. Hartt in the Devonian rocks of New Brunswick. This fossil, and those accompanying it, are the oldest insect-remains in the world.

Fig. 6. Three facets from the eye of an insect, considered by Dr. Dawson a Dragon-fly. It was found in coprolites of reptiles in the rocks containing the Myriapod, represented in Fig. 4. Copied from Dr. Dawson's figure, greatly magnified.

Fig. 7. *Homothetus fossilis.* A Neuropterous insect from the Devonian rocks of New Brunswick; it was discovered by Mr. Hartt.

Fig. 8. *Haplophlebium Barnesii.* A curious Neuropterous insect, of large size, probably allied to our May-flies; taken by Mr. Barnes from the coal of Cape Breton.

These figures, with the exception of 1, 4, and 6, are of life size, and borrowed from the new edition of Dr. Dawson's Acadian Geology.

the characters of the Neuroptera and Hemiptera. It is gigantic, spreading eight or nine inches; its body must have measured six inches in length.

In the Mesozoic rocks, the celebrated Solenhofen locality in Bavaria is rich in Liassic insect-remains. Dr. Hagen (Entomologist's Annual, London, 1862) states that among the Solenhofen fossils the Neuroptera and Orthoptera are most largely represented; as out of four hundred and fifty species of insects, one hundred and fifty are Neuroptera, of which one hundred and thirty-six are Dragon-flies, and besides "there is a *Corydalus*, one *Chrysopa*, a large *Apochrysa*, and a beautiful *Nymphes*. The last two genera, which do not seem very remote from *Chrysopa*, are now found only in the Southern Hemisphere, *Nymphes* is peculiarly an Australian genus."

The Lias of England is very rich in fossil insects, especially the Purbeck and Rhoetic Beds (see Brodie's Work on Fossil Insects and also Westwood in the Geological Journal, etc. Vol. X.).

In the Trias, or New-Red Sandstone of the Connecticut Valley, Professor Hitchcock has found numerous remains of the larva of an aquatic insect.

The insects of the Tertiary formation more closely resemble those of the present day. The most celebrated European locality is Œningen in Switzerland.

According to Professor O. Heer, over five thousand specimens of fossil insects have been found at Œningen, comprising 844 species, of which 518 are Coleopterous. From all Tertiary Europe there are 1,322 species, as follows: 166 Hymenoptera, 18 Lepidoptera, 166 Diptera, 660 Coleoptera, 217 Hemiptera, 39 Orthoptera, and 56 Neuroptera.

"If we inquire to what insect-fauna of the present period the Tertiary fauna is most analogous, we shall be surprised to find that most of the species belong to genera actually found in the old and the new world. The insect-fauna of Œningen contains 180 genera of this category, of which 114 belong to the Coleoptera. Of these last, two (*Dineutes* and *Caryborus*) remain in Europe, while all the others are now found living both in Europe and in America. The whole number of Coleopterous genera furnished by Œningen, and known to me, amount to

158; those that are common to both hemispheres forming then more than two-thirds of the whole number, while of the actual Coleopterous fauna of Europe, according to the calculation of M. Lacordaire, there is only one-third. The genera found to-day in both parts of the world have then during the Tertiary epoch played a more important part than is the case now; hence the knowledge of the character of the fauna is rendered more difficult. We find at Œningen but a very small number (five) of genera exclusively European; seventeen are found to-day in Europe, in Asia, and in Africa, but not in America. For the most part they belong to the Mediterranean fauna (comprising eight genera) and give to the insect-fauna of Œningen a strong proportion of Mediterranean forms. In this fauna I only know of one exclusively Asiatic genus; two are peculiar to Africa, and two others (*Anoplites* and *Naupactus*) are American.

"There are now living, however, in Europe certain genera which, without being exclusively American, since they are found in Asia and in Africa, belong more peculiarly to America; such are *Belostomum*, *Hypselonotus*, *Diplonychus*, *Evagorus*, *Stenopoda*, *Plecia*, *Caryborus*, and *Dineutes*. . . . The genera peculiar to our fauna of Tertiary insects amount to forty-four, of which twenty-one belong to the Coleoptera; among the Orthoptera there is one, and six Hymenoptera, six Diptera, and eleven Hemiptera. They comprise 140 species." (Heer.)

An apparently still richer locality for Tertiary insects has been discovered by Professor Denton west of the Rocky Mountains, near the junction of the White and Green Rivers, Colorado. According to Mr. Scudder "between sixty and seventy species of insects were brought home, representing nearly all the different suborders; about two-thirds of the species were Flies,—some of them the perfect insect, others the maggot-like larvæ,—but, in no instance, did both imago and larva of the same insect occur. The greater part of the beetles were quite small; there were three or four kinds of Homoptera (allied to the tree-hoppers), Ants of two different genera, and a poorly preserved Moth. Perhaps a minute *Thrips*, belonging to a group which has never been found fossil in any part of the world, is of the greatest interest."

He thus sums up what is known of American fossil insects.

"The species of fossil insects now known from North America, number eighty-one: six of these belong to the Devonian, nine to the Carboniferous, one to the Triassic, and sixty-five to the Tertiary epochs. The Hymenoptera, Homoptera, and Diptera occur only in the Tertiaries; the same is true of the Lepidoptera, if we exclude the Morris specimen, and of the Coleoptera, with one Triassic exception. The Orthoptera and Myriapods are restricted to the Carboniferous, while the Neuroptera occur both in the Devonian and Carboniferous formations. No fossil Spiders have yet been found in America." (American Naturalist, vol. 1, p. 630.) One species of Spider has been found in the Coal-measures of Europe, and a large number in Prussian Amber.

The Diseases of Insects have attracted but little attention. They are so far as known mostly the result of the attacks of parasitic plants and animals, though epidemics are known to break out and carry off myriads of insects. Dr. Shimer gives an account of an epidemic among the Chinch bugs, which "was at its maximum during the moist warm weather that followed the cold rains of June and the first part of July, 1865."

Species of microscopic plants luxuriate in infinitesimal forests within the alimentary canal of some wood-devouring insects, and certain fungi attack those species which are exposed to dampness, and already enfeebled by other causes. Among the true *entophyta*, or parasitic plants, which do not however ordinarily occasion the death of their host, Professor Leidy describes *Enterobryus elegans*, *E. spiralis*, *E. alternatus*, *Arthromitus cristatus*, *Cladophytum comatum*, and *Corynocladus radiatus*, which live mostly attached to the mucous walls of the interior of the intestine of *Julus marginatus* and two other species of *Julus*, and *Passalus cornutus*. *Eccrina longa* Leidy, lives in *Polydesmus Virginiensis;* and *E. moniliformis* Leidy in *P. granulatus*.

But there are parasitic fungi that are largely destructive to their hosts. Such are *Sphaeria* and *Isaria*. "These fungi grow with great rapidity within the body of the animal they attack, not only at the expense of the nutritive fluids of the latter, but, after its death, all the interior soft tissues appear

to be converted into one or more aerial receptacles of spores." (Leidy.) These fungi, so often infesting caterpillars, are hence called "caterpillar fungi." They fill the whole body, distending even the legs, and throw out long filaments, sometimes longer than the larva itself, giving a grotesque appearance to the insect. Leidy has found a species which is very common in the Seventeen-year Locust, *Cicada septendecim.* He found "among myriads of the imago between twelve and twenty specimens, which, though living, had the posterior third of the abdominal contents converted into a dry, powdery, ochreous-yellow, compact mass of sporuloid bodies." He thinks this Cicada is very subject to the attacks of these fungi, and that the spores enter the anal and genital passages more readily than the mouth; thus accounting for their development in the abdomen.

The most formidable disease is the "*Muscardine*," caused by a fungus, the *Botrytus Bassiana* of Balsamo. It is well known that this disease has greatly reduced the silk crop in Europe. Balbiani has detected the spores of this fungus in the eggs of *Bombyx mori* as well as in the different parts of the body of the insect in all stages of growth. Extreme cleanliness and care against contagion must be observed in its prevention.

Among plants a disease like Muscardine, due to the presence of a minute fungus (*Mucor mellitophorus*), fills the stomach of some insects, including the Honey-bee, with its colorless spores, and greatly weakens those affected. Another fungus, *Sporendonema musca*, infests the common House-fly.

Another Silk-worm disease called "*Pebrine*," carries off many silk-worms. Whether it is of pathological or vegetable origin is not yet settled.

There are also a few intestinal worms known to be parasitic in insects. The well-known "Hair-worm" (*Gordius*) in its young state lives within the body of various insects including the Spiders. The tadpole-like young differs greatly from the parent, being short, sac-like, ending in a tail. Upon leaving the egg they work their way into the body of insects, and there live on the fatty substance of their hosts, where they undergo their metamorphosis into the adult hair-like worm, and make their way to the pools of water in which they live

and beget their species, and lay "millions of eggs connected together in long cords." Leidy thus writes regarding the habits of a species which infests grasshoppers.

"The number of *Gordii* in each insect varies from one to five, their length from three inches to a foot; they occupy a position in the visceral cavity, where they lie coiled among the viscera, and often extend from the end of the abdomen forward through the thorax even into the head; their bulk and weight are frequently greater than all the soft parts, including the muscles, of their living habitation. Nevertheless, with this relatively immense mass of parasites, the insects jump about almost as freely as those not infested.

"The worms are milk-white in color, and undivided at the extremities. The females are distended with ova, but I have never observed them extruded. When the bodies of Grasshoppers, containing these entozoa, are broken and lain upon moist earth, the worms gradually creep out and pass below its surface."

Goureau states that *Filaria*, a somewhat similar worm, inhabits *Hibernia brumata* and *Vanessa prorsa.* (Ann. Ent. Soc. France.)

Siebold describes *Gordius subbifurcus* which infests the Honey-bee, especially the drones, though it is rather the workers, which frequent the pools where the Gordii live, that we would expect to find thus infested. Another entozoan is *Mermis albicans* of Siebold, which is a very slender whitish worm much like *Gordius*, and about five inches long. It is found in the drone of the honey-bee and in some other insects.

Deformities of Insects. Numerous instances of supernumerary legs and antennæ are recorded. The antennæ are sometimes double, but more commonly the legs. "Of these Asmuss has collected eight examples, and it is remarkable that in six of them the parts on one side are treble." Newport, from whom we have quoted, states that "the most remarkable example is that given by Lefebvre of *Scarites Pyrachmon* in which from a single coxa on the left side of the prosternum two trochanters originated. The anterior one, the proper trochanter, supported the true prothoracic leg; while the posterior one, in the form of an oblong lanceolate body, attached to the base of

the first, supported two additional legs equally well formed as the true one."

The wings are often partially aborted and deformed; this is especially noticeable in the wings of butterflies and moths.


Fig. 69.

Mr. F. G. Sanborn has described and figured a wing of a female of *Libellula luctuosa* Burm. (Fig. 69), in which among other deformities "the pterostigma is shorter and broader than that of the opposite wing, and is situated about one-eighth of an inch only from the nodus, only *one* cubital vein occurring between them, instead of fourteen as in the opposite wing." (Proceedings of the Boston Society of Natural History, vol. xi, p. 326.)

Directions for Collecting and Preserving Insects. Insects differ sexually in that the female generally appears to have one abdominal ring less (one ring disappearing during the semi-pupa state, when the ovipositor is formed), and in being larger, fuller, and duller colored than the males, while the latter often differ in sculpture and ornamentation. In collecting, whenever the two sexes are found united they should be pinned upon the same pin, the male being placed highest. When we take one sex alone, we may feel sure that the other is somewhere in the vicinity; perhaps while one is flying about so as to be easily captured, the other is hidden under some leaf, or resting on the trunk of some tree near by, which must be examined and every bush in the vicinity vigorously beaten by the net. Many species rare in most places have a *metropolis* where they occur in great abundance. During seasons when his favorites are especially abundant the collector should lay up a store against years of scarcity.

At no time of the year need the entomologist rest from his labors. In the winter, under the bark of trees and in moss he can find many species, or on trees, etc., detect their eggs, which he can mark for observation in the spring when they hatch out.

He need not relax his endeavors day or night. Mothing is night employment. Skunks and toads entomologize at night. Early in the morning, at sunrise, when the dew is still on the leaves, insects are sluggish and easily taken with the hand;

so at dusk, when many species are found flying, and in the night, the collector will be rewarded with many rarities, many species flying then that hide themselves by day, while many caterpillars leave their retreats to come out and feed, when the lantern can be used with success in searching for them.

Wollaston (Entomologist's Annual, 1865) states that sandy districts, especially towards the coast, are at all times preferable to clayey ones, but the intermediate soils, such as the loamy soil of swamps and marshes are more productive. Near the sea, insects occur most abundantly beneath pebbles and other objects in grassy spots, or else at the roots of plants. In many places, especially in Alpine tracts, as we have found on the summit of Mt. Washington and in Labrador, one has to lie down and look carefully among the short herbage and in the moss for Coleoptera.

The most advantageous places for collecting are gardens and farms, the borders of woods and the banks of streams and ponds. The deep, dense forests, and open, treeless tracts are less prolific in insect life. In winter and early spring the moss on the trunks of trees, when carefully shaken over a newspaper or white cloth, reveal many beetles and Hymenoptera. In the late summer and autumn, toadstools and various fungi and rotten fruits attract many insects, and in early spring when the sap is running we have taken rare insects from the stumps of freshly cut hard-wood trees. Wollaston says, "Dead animals, partially-dried bones, as well as the skins of moles and other vermin which are ordinarily hung up in fields are magnificent traps for Coleoptera; and if any of these be placed around orchards and inclosures near at home, and be examined every morning, various species of *Nitidulæ*, *Silphidæ*, and other insects of similar habits, are certain to be enticed and captured.

"Planks and chippings of wood may be likewise employed as successful agents in alluring a vast number of species which might otherwise escape our notice, and if these be laid down in grassy places, and carefully inverted every now and then with as little violence as possible, many insects will be found adhering beneath them, especially after dewy nights and in showery weather. Nor must we omit to urge the importance

of examining the under sides of stones in the vicinity of ants' nests, in which position, during the spring and summer months, many of the rarest of our native Coleoptera may be occasionally procured." Excrementitious matter always contains many interesting forms in various stages of growth.

The trunks of fallen and decaying trees offer a rich harvest for many wood-boring larvæ, especially the Longicorn beetles, and weevils can be found in the spring, in all their stages. Numerous carnivorous Coleopterous and Dipterous larvæ dwell within them, and other larvæ which eat the dust made by the borers. The inside of pithy plants like the elder, raspberry, blackberry, and syringa, are inhabited by many of the wild bees, *Osmia*, *Ceratina*, and the wood-wasps, *Crabro*, *Stigma*, etc., the habits of which, with those of their Chalcid and Ichneumon parasites, offer endless amusement and study.

Ponds and streams shelter a vast throng of insects, and should be diligently dredged with the water-net, and stones and pebbles should be overturned for aquatic beetles, Hemiptera, and Dipterous larvæ.

The various sorts of galls should be collected in spring and autumn and placed in vials or boxes, where they may be reared, and the rafters of out-houses, stone-walls, etc., should be carefully searched for the nests of Mud-wasps.

Collecting Apparatus. First in importance is the *net.* This is made by attaching a ring of brass wire to a handle made to slide on a pole six feet long. The net may be a foot in diameter, and the bag itself made of thin gauze or mosquito-netting (the finer, lighter, and more durable the better), and should be about twenty inches deep. It should be sewed to a narrow border of cloth placed around the wire. A light net like this can be rapidly turned upon the insect with one hand. The insect is captured by a dexterous twist which also throws the bottom over the mouth of the net. The insect should be temporarily held between the thumb and fore-finger of the hand at liberty, and then pinned through the thorax while in the net. The pin can be drawn through the meshes upon opening the net. The *beating-net* should be made much stouter, with a shallower cloth bag and attached to a shorter stick. It is used for beating trees, bushes, and herbage for beetles and Hemiptera

and various larvæ. Its thorough use we would recommend in the low vegetation on mountains and in meadows. The *water-net* may be either round or of the shape indicated in Fig. 70. The ring should be made of brass, and the shallow net of grass-cloth or coarse millinet. It is used for collecting aquatic insects.

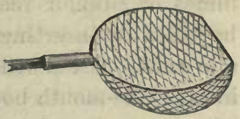


Fig. 70.

Various sorts of *forceps* are indispensable for handling insects. Small delicate narrow-bladed forceps with fine sharp points in use by jewellers, and made either of steel or brass, are excellent for handling minute specimens. For larger ones long curved forceps are very convenient. For pinning insects into boxes the forceps should be stout, the blades blunt and curved at the end so that the insect can be pinned without slanting the forceps much. The ends need to be broad and finely indented by lines so as to firmly hold the pin. With a little practice the forceps soon take the place of the fingers. They will have to be made to order by a neat workman or surgical-instrument maker. Some persons use the ordinary form of pliers with curved handles, but they should be long and slender. A spring set in to separate the handles when not grasped by the hand is a great convenience.

Various pill-boxes, vials, and bottles must always be taken, some containing alcohol or whiskey. Many collectors use a wide-mouth bottle, containing a sponge saturated with ether, chloroform, or benzine, or bruised laurel leaves, the latter being pounded with a hammer and then cut with scissors into small pieces, which give out exhalations of prussic acid strong enough to kill most small insects.

Besides these the collector needs a small box lined with corn-pith, or cork, and small enough to slip into the coat-pocket; or a larger box carried by a strap. Most moths and small flies can be pinned alive without being pinched (which injures their shape and rubs off the scales and hairs), and then killed by pouring a little benzine into the bottom of the box.

Killing Insects for the Cabinet. Care in killing affects very sensibly the looks of the cabinet. If hastily killed and distorted by being pinched, with the scales rubbed off and otherwise mangled, the value of such a specimen is diminished

either for purposes of study or the neat appearance of the collection.

Besides the vapor of ether, chloroform, and benzine, the fumes of sulphur readily kill insects. Large specimens may be killed by inserting a pin dipped in a strong solution of oxalic acid. An excellent collecting bottle is made by putting into a wide-mouth bottle two or three small pieces of cyanide of potassium, which may be covered with cotton, about half-filling the bottle. The cotton may be covered with paper lightly attached to the glass and pierced with pin-holes; this keeps the insect from being lost in the bottle. For Diptera, Loew recommends moistening the bottom of the collecting box with creosote. This is excellent for small flies and moths, as the mouth of the bottle can be placed over the insect while at rest; the insect flies up into the bottle and is immediately suffocated. A bottle well prepared will, according to Laboulbène, last several months, even a year, and is vastly superior to the old means of using ether or chloroform. He states, "the inconvenience of taking small insects from a net is well known, as the most valuable ones usually escape; but by placing the end of the net, filled with insects, in a wide-mouthed bottle, and putting in the cork for a few minutes, they will be suffocated."

Pinning Insects. The pin should be inserted through the thorax of most insects. The Coleoptera, however, should be pinned through the right wing-cover; many Hemiptera are best pinned through the scutellum. The specimens should all be pinned at an equal height, so that about one-fourth of the pin should project above the insect.

The best pins are those made in Berlin by Klager. They are of five sizes, No. 1 being the smallest; Nos. 1, 2, and 5 are the most convenient. For very minute insects still smaller pins are made. A very good but too short pin is made by Edleston and Williams, Crown Court, Cheapside, London. Their Nos. 19 and 20 may be used to impale minute insects upon, and then stuck through a bit of cork, or pith, through which a No. 5 Klager pin may be thrust. Then the insect is kept out of the reach of devouring insects. Still smaller pins are made by cutting off bits of very fine silvered wire at the right length, which may be thrust by the forceps into a piece of pith, after the insects have been impaled upon them.

Small insects, especially beetles, may be mounted on cards or pieces of mica through which the pin may be thrust. The French use small oblong bits of mica, with the posterior half covered with green paper on which the number may be placed. The insect may be gummed on the clear part, the two sexes together. The under side can be seen through the thin mica.

Others prefer triangular pieces of card, across the end of which the insect may be gummed, so that nearly the whole under side is visible.

Mr. Wollaston advocates gumming small Coleoptera upon cards. Instead of cutting the pieces of cards first, he gums them promiscuously upon a sheet of card-board. "Having gummed thickly a space on your card-board equal to, at least, the entire specimen when expanded, place the beetle upon it, drag out the limbs with a pin, and, leaving it to dry, go on with the next one that presents itself. As the card has to be cut afterwards *around* your insect (so as to suit it), there is no advantage in gumming it precisely *straight upon your frame*, — though it is true that a certain amount of care in this respect lessens your after labor of cutting-off very materially. When your frame has been filled, and you are desirous of separating the species, cut out the insect with finely pointed scissors."

For mending broken insects, *i.e.* gumming on legs and antennæ which have fallen off, inspissated ox-gall, softened with a little water, is the best gum.

For gumming insects upon cards Mr. Wollaston recommends a gum "composed of three parts of tragacanth to one of Arabic, both in powder; to be mixed in water containing a grain of corrosive sublimate, without which it will not keep, until of a consistency just thick enough to run. As this gum is of an extremely absorbent nature, nearly a fortnight is required before it can be properly made. The best plan is to keep adding a little water (and stirring it) every few days until it is of the proper consistency. It is advisable to dissolve the grain of corrosive sublimate in the water which is poured *first* upon the gum."

Preservative Fluids. The best for common use is alcohol, diluted with a little water; or whiskey, as alcohol of full strength is too strong for caterpillars, etc., since it shrivels them

up. Glycerine is excellent for preserving the colors of caterpillars, though the internal parts decay somewhat, and the specimen is apt to fall to pieces on being roughly handled.

Laboulbène recommends for the preservation of insects in a fresh state plunging them in a preservative fluid consisting of alcohol with an excess of arsenic acid in fragments, or the common white arsenic of commerce. A pint and a half of alcohol will take about fourteen grains (troy) of arsenic. The living insect, put into this preparation, absorbs about $\frac{3}{1000}$ of its own weight. When soaked in this liquor and dried, it will be safe from the ravages of Moths, *Anthrenus*, or *Dermestes*. This liquid will not change the colors of blue, green, or red beetles if dried after soaking from twelve to twenty-four hours. Hemiptera and Orthoptera can be treated in the same way.

A stay of a month in this arseniated alcohol mineralizes the insect, so that it appears very hard, and, after drying, becomes glazed with a white deposit which can, however, be washed off with alcohol. In this state the specimens become too hard for dissection and study, but will do for cabinet specimens designed for permanent exhibition.

Another preparation recommended by Laboulbène is alcohol containing a variable quantity of corrosive sublimate, but the latter has to be weighed, as the alcohol evaporates easily, the liquor becoming stronger as it gets older. The strongest solution is one part of corrosive sublimate to one hundred of alcohol; the weakest and best is one-tenth of a part of corrosive sublimate to one hundred parts of alcohol. Insects need not remain in this solution more than two hours before drying. Both of these preparations are very poisonous and should be handled with care. The last-named solution preserves specimens from mould, which will attack pinned insects during damp summers.

A very strong brine will preserve insects until a better liquor can be procured. Professor A. E. Verrill recommends two simple and cheap solutions for preserving, among other specimens, the larvæ of insects "with their natural color and form remarkably perfect." The first consists of two and a half pounds of common salt and four ounces of nitre dissolved in a gallon of water, and filtered. Specimens should be prepared for permanent preservation in this solution by being previously immersed

in a solution consisting of a quart of the first solution and two ounces of arseniate of potash and a gallon of water. (Proceedings Boston Society Nat. Hist., vol. x, p. 257.)

The nests, cocoons, and chrysalids of insects may be preserved from injury from other insects by being soaked in the arseniated alcohol, or dipped into benzine, or a solution of carbolic acid or creosote.

Preparing Insects for the Cabinet. Dried insects may be moistened by laying them for twelve or twenty-four hours in a box containing a layer of wet sand, covered with one thickness of soft paper. Their wings can then be easily spread. *Setting-boards* for spreading the wings of insects may be made by sawing deep grooves in a thick board, and placing a strip of pith or cork at the bottom. The groove may be deep enough to allow a quarter of the length of the pin to project above the insect. The setting-board usually consists of thin parallel strips of board, leaving a groove between them wide enough to receive the body of the insect, at the bottom of which a strip of cork or pith should be glued. The ends of the strips should be nailed on to a stouter strip of wood, raising the surface of the setting-board an inch and a half so that the pins can stick through without touching. Several setting-boards can be made to form shelves in a frame covered with wire gauze, so that the specimens may be preserved from dust and destructive insects, while the air may at the same time have constant access to them. The surface of the board should incline a little towards the groove for the reception of the insect, as the wings often gather a little moisture, relax and fall down after the insect is dried. Moths of medium size should remain two or three days on the setting-board, while the larger thick-bodied Sphinges and *Bombycidæ* require a week to dry. The wings can be arranged by means of a needle stuck into a handle of wood. They should be set horizontally, and the front margin of the fore-wings drawn a little forward of a line perpendicular to the body, so as to free the inner margin of the hind wings from the body, that their form may be distinctly seen. When thus arranged, they can be confined by pieces of card pinned to the board as indicated in figure 71, or, as we prefer, by square pieces of glass laid upon them.

After the insects have been thoroughly dried they should not be placed in the cabinet until after having been in quarantine to see that no eggs of Dermestes or Anthrenus, etc., have been deposited on them.

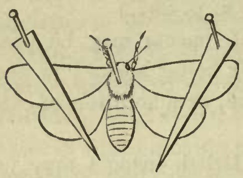


Fig. 71.

For preserving dried insects in the cabinet Laboulbène recommends placing a rare insect (if a beetle or any other hard insect) in water for an hour until the tissues be softened. If soiled, an insect can be cleansed under water with a fine hair-pencil, then submit it to a bath of arseniated alcohol, or, better, alcohol with corrosive sublimate. If the insect becomes prune-colored, it should be washed in pure alcohol several times. This method will do for the rarest insects; the more common ones can be softened on wet sand, and then the immersion in the arseniated alcohol suffices. After an immersion of an hour or a quarter of an hour, according to the size of the insect, the pin is not affected by the corrosive sublimate, but it is better to unpin the insect previous to immersion, and then pin it when almost dry.

For cleaning insects ether or benzine are excellent, applied with a hair-pencil; though care should be taken in using these substances which are very inflammable.

After the specimens are placed in the cabinet, they should be farther protected from destructive insects by placing in the drawers or boxes pieces of camphor wrapped in paper perforated by pin-holes, or bottles containing sponges saturated with benzine. The collection should be carefully examined every month; the presence of insects can be detected by the dust beneath them. Where a collection is much infested with destructive insects, benzine should be poured into the bottom of the box or drawer, when the fumes and contact of the benzine with their bodies will kill them. The specimens themselves should not be soaked in the benzine if possible, as it renders them brittle.

Insect-cabinet. For permanent exhibition, a cabinet of shallow drawers, protected by doors, is most useful. A drawer may be eighteen by twenty inches square, and two inches deep in the clear, and provided with a tight glass cover. For constant

use, boxes made of thin, well-seasoned wood, with tight-fitting covers, are indispensable. For Coleoptera, Dr. Leconte recommends that they be twelve by nine inches (inside measurement). For the larger Lepidoptera a little larger box is preferable. Others prefer boxes made in the form of books, which may be put away like books on the shelves of the cabinet, though the cover of the box is apt to be in the way.

The boxes and drawers should be lined with cork cut into thin slips for soles; such slips come from the cork-cutter about twelve by four inches square, and an eighth of an inch thick. A less expensive substitute is paper stretched upon a frame. Mr. E. S. Morse has given in the American Naturalist (vol. I, p. 156) a plan which is very neat and useful for lining boxes in a large museum, and which are placed in horizontal show-cases (Fig. 72). "A box is made of the required depth, and a light frame is fitted to its interior. Upon the upper and under surfaces of this frame, a sheet of white paper (drawing or log-paper answers the purpose) is securely glued.

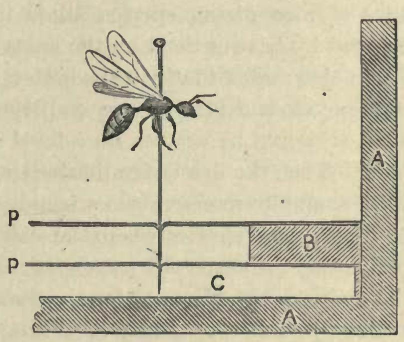


Fig. 72.

The paper, having been previously dampened, in drying contracts and tightens like a drum-head. The frame is then secured about one-fourth of an inch from the bottom of the box, and the pin is forced down through the thicknesses of paper, and if the bottom of the box be of soft pine, the point of the pin may be slightly forced into it. It is thus firmly held at two or three different points, and all lateral movements are prevented. Other advantages are secured by this arrangement besides firmness; when the box needs cleaning or fumigation, the entire collection may be removed by taking out the frame, or camphor, tobacco, or other material can be placed on the bottom of the box, and concealed from sight. The annexed figure represents a transverse section of a portion of the side and bottom of the box with the frame. A, A, box; B, frame;

P, P, upper and under sheets of paper; C, space between lower sheet of paper and bottom of box."

Other substitutes are the pith of various plants, especially of corn; and palm wood, and "inodorous felt" is used, being cut to fit the bottom of the box.

Leconte recommends that "for the purpose of distinguishing specimens from different regions, little disks of variously colored paper be used; they are easily made by a small punch, and should be kept in wooden pill-boxes ready for use; at the same time a key to the colors, showing the regions embraced by each, should be made on the fly-leaf of the catalogue of the collection." He also strongly recommends that the "specimens should all be pinned at the same height, since the ease of recognizing species allied in characters is greatly increased by having them on the same level."

He also states that "it is better, even when numbers with reference to a catalogue are employed, that the name of each species should be written on a label attached to the first specimen. Thus the eye is familiarized with the association of the species and its name, memory is aided, and greater power given of identifying species when the cabinet is not at hand." For indicating the sexes the astronomical sign ♂ (Mars) is used for the male, and ♀ (Venus) for the female, and ☿ for the worker.

Transportation of Insects. While travelling, all hard-bodied insects, comprising many Hymenoptera, the Coleoptera, Hemiptera, and many Neuroptera should be thrown, with their larvæ, etc., into bottles and vials filled with strong alcohol. When the bottle is filled new liquor should be poured in, and the old may be saved for collecting purposes; in this way the specimens will not soften and can be preserved indefinitely, and the colors do not, in most cases, change. Leconte states that "if the bottles are in danger of being broken, the specimens, after remaining for a day or two in alcohol, may be taken out, partially dried by exposure to the air, but not so as to be brittle, and these packed in layers in small boxes between soft paper; the boxes should then be carefully closed with gum-paper or paste, so as to exclude all enemies."

Lepidoptera and Dragon-flies and other soft-bodied insects may be well preserved by placing them in square pieces of pa-

per folded into a triangular form with the edges overlapping. Put up thus, multitudes can be packed away in tin boxes, and will bear transportation to any distance. In tropical climates, chests lined with tin should be made to contain the insect-boxes, which can thus be preserved against the ravages of white ants, etc.

In sending live larvæ by mail, they should be inclosed in little tin boxes, and in sending dry specimens, the box should be light and strong, and directions given at the post-office to stamp the box lightly. In sending boxes by express they should be carefully packed in a larger box, having an interspace of two inches, which can be filled in tightly with hay or crumpled bits of paper. Beetles can be wrapped in pieces of soft paper. Labels for alcoholic specimens should consist of parchment with the locality, date of capture, and name of collector written in ink. A temporary label of firm paper with the locality, etc., written with a pencil, will last for several years.

Preservation of Larvæ. Alcoholic specimens of insects, in all stages of growth, are very useful. Few collections contain alcoholic specimens of the adult insect. This is a mistake. Many of the most important characters are effaced during the drying process, and for purposes of general study alcoholic specimens, even of Bees, Lepidoptera, Diptera, and Dragon-flies are very necessary.

Larvæ, generally, may be well preserved in vials or bottles of alcohol. They should first be put into whiskey, and then into alcohol. If placed in the latter first, they shrivel and become distorted. Mr. E. Burgess preserves caterpillars with the colors unchanged, by immersing them in boiling water thirty or forty seconds, and then placing them in equal parts of alcohol and water. It is well to collect larvæ and pupæ indiscriminately, even if we do not know their adult forms; we can approximate to them, and in some cases tell very exactly what they must be.

Rearing Larvæ. More attention has been paid to rearing Caterpillars than the young of any other suborder of insects, and the following remarks apply more particularly to them, but

very much the same methods may be pursued in rearing the larvæ of Beetles, Flies, and Hymenoptera. Subterranean larvæ have to be kept in moist earth, aquatic larvæ must be reared in aquaria, and carnivorous larvæ must be supplied with flesh. The larvæ of Butterflies are rare; those of moths occur more frequently, while their imagos may be scarce. In some years many larvæ, which are usually rare, occur in abundance, and should then be reared in numbers. In hunting for caterpillars bushes should be shaken and beaten over newspapers or sheets, or an umbrella; herbage should be swept, and trees examined carefully for leaf-rollers and miners. The best specimens of moths and butterflies are obtained by rearing them from the egg, or from the larva or pupa. In confinement the food should be kept fresh, and the box well ventilated. Tumblers covered with gauze, pasteboard boxes pierced with holes and fitted with glass in the covers, or large glass-jars, are very convenient to use as cages. The bottom of such vessels may be covered with moist sand, in which the food-plant of the larva may be stuck and kept fresh for several days. Larger and more airy boxes, a foot square, with the sides of gauze, and fitted with a door, through which a bottle of water may be introduced, serve well. The object is to keep the food-plant fresh, the air cool, the larva out of the sun, and in fact everything in such a state of equilibrium that the larva will not feel the change of circumstances when kept in confinement. Most caterpillars change to pupæ in the autumn; and those which transform in the earth should be covered with earth, kept damp by wet moss, and placed in the cellar until the following summer. The collector in seeking for larvæ should carry a good number of pill-boxes, and especially a close tin box, in which the leaves may be kept fresh for a long time. The different forms and markings of caterpillars should be noted, and they should be drawn carefully together with a leaf of the food-plant, and the drawings and pupa skins, and perfect insect, be numbered to correspond. Descriptions of caterpillars cannot be too carefully made, or too long. The relative size of the head, its ornamentation, the stripes and spots of the body, and the position and number of tubercles, and the hairs, or fascicles of hairs, or spines and spinules,

which arise from them, should be noted, besides the general form of the body. The lines along the body are called *dorsal*, if in the middle of the back, *subdorsal;* if upon one side, *lateral*, and *ventral* when on the sides and under surface, or *stigmatal* if including the *stigmata* or breathing pores, which are generally parti-colored. Indeed, the whole biography of an insect should be ascertained by the observer; the points to be noted are:

1. Date, when and how the *eggs* are laid; and number, size, and marking of the eggs.

2. Date of hatching, the appearance, food-plant of *larva*, and number of days between each moulting; the changes the larva undergoes, which are often remarkable, especially before the last moulting, with drawings illustrative of these; the habits of the larva, whether solitary or gregarious, whether a day or night feeder; the Ichneumon parasites, and their mode of attack. Specimens of larvæ in the different moultings should be preserved in alcohol. The appearance of the larvæ when full-fed, the date, number of days before pupating, the formation and description of the cocoon, the duration of larvæ in the cocoon before pupation, their appearance just before changing, their appearance while changing, and alcoholic specimens of larvæ in the act, should all be studied and noted.

3. Date of pupation; description of the pupa or chrysalis; duration of the pupa state, habits, etc.; together with alcoholic specimens, or pinned dry ones. Lepidopterous pupæ should be looked for late in the summer or in the fall and spring, about the roots of trees, and kept moist in mould until the imago appears. Many Coleopterous pupæ may also occur in mould, and if aquatic, under submerged sticks and stones, and those of borers under the bark of decaying trees.

4. Date when the insect escapes from the pupa, and method of escape; duration of life of the imago; and the number of broods in a season.

Entomological Works. The titles of a few of the most important works on Insects are given below. The more advanced student should, however, possess Dr. Hagen's Bibliotheca Entomologica, 8vo, 2 vols., Leipzig, 1862–3, which contains a

complete list of all entomological publications up to the year 1862. Besides these he should consult the annual reports on the progress of Entomology published in Wiegmann's Archiv für Naturgeschichte, begun in 1834, and continued up to the present time; and also Günther's Zoölogical Record (8vo, Van Voorst, London), beginning with the year 1864. Occasional articles are also scattered through the various government reports, and those of agricultural societies and agricultural papers.

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ENTOMOLOGICAL JOURNAL. Every collector should keep a daily journal of his captures and observations, noting down every fact and hint that falls under his notice. In this book, commenced as soon as the season opens in early spring, can be placed on record the earliest appearance, the time of greatest abundance, and the disappearance of every insect in any of its stages. Also the descriptions of larvæ, with sketches, and observations upon their habits; though drawings had better be kept upon separate pieces of paper for easier reference. The insects, when captured and unnamed should be numbered to agree with corresponding numbers in the note-book. At the close of the season one will be surprised to see how much material of this kind has accumulated. He can then make a *calendar of appearances* of perfect insects and larvæ, so as to have the work of the next season portioned out to him; he will thus know when and where to look for any particular insect or caterpillar.

THE NUMBER OF SPECIES OF INSECTS. Oswald Heer estimates that the Insects comprise four-fifths of the whole animal kingdom. While there are about 55,000 species of animals known, excluding the Insects, the number of this last single class amounts to upwards of 190,000 known species, according to

Gerstaecker's estimate. He reckons that there are at least 25,000 species of Hymenoptera, from 22,000 to 24,000 Lepidoptera, about 24,000 Diptera, and 90,000 Coleoptera; the number of the other suborders cannot be easily estimated. Besides these there are about 4,600 Arachnida, and 800 Myriapods.

Grouping of Insects into Orders and Suborders. Before beginning an account of the Six-footed Insects, we present the following tabular view of the Classification of Insects. The idea that the Myriapods, Spiders, and Six-footed Insects formed orders and not classes was first proposed by R. Leuckart in 1848, and afterwards supported by Agassiz and Dana. The arrangements proposed by these and other authors are put in tabular form on page 106.

The Class of Insects.

Order I. — Segments grouped into three distinct regions; eyes compound and simple; two pairs of wings;* three pairs of thoracic legs; one pair of jointed abdominal appendages. A more or less complete metamorphosis, ...	Hexapoda (Six-footed Insects).
Order II. — Segments grouped into two regions, a false cephalothorax † and an abdomen; no antennæ; eyes simple; wingless; four pairs of thoracic legs; three pairs of jointed abdominal appendages (spinnerets) often present. No metamorphosis, . .	Arachnida (Spiders).
Order III. — Body cylindrical, worm-like. Segments not grouped into regions (except in the recently hatched young). Head free; eyes simple; antennæ present; wingless; yelk-sac present for a short period after hatching. No metamorphosis,	Myriapoda (Centipedes).

The Order of Six-footed Insects ‡ (*Hexapoda*).

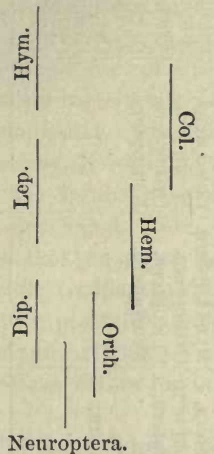
First and higher series. Body usually cylindrical; prothorax small; mouth-parts more generally haustellate (formed for sucking); metamorphosis complete; pupa inactive; larva usually cylindrical, very unlike the adult, ...	Hymenoptera. Lepidoptera. Diptera
Second and lower series. Body usually flattened; prothorax large and squarish; mouth-parts usually adapted for biting; metamorphosis incomplete; pupa often inactive; larva flattened, often resembling the adult, ...	Coleoptera. Hemiptera. Orthoptera. Neuroptera.

*The number of wingless forms is comparatively few. The Diptera have but one pair.

†The so-called "cephalothorax" of Spiders is not like that region in the Crabs, the head being much freer from the thorax.

‡Leuckart's classification is an advance on others in his considering the Hexapoda, Arachnida, and Myriapoda as orders instead of classes, but he says nothing

The following diagram shows, in a rude way, the relative rank and affinities of the seven suborders, and of the two series of Six-footed Insects.



Through *Lepisma*, and *Podura* which are wingless Neuropterous insects, the lower series is connected with the Myriapods, the minute degraded myriapod, *Pauropus* of Lubbock, perhaps forming the connecting link; and through the wingless flies, *Braula*, *Chionea*, and *Nycteribia*, the Diptera, belonging to the higher series, assume the form of the Spiders, the head being small, and sunken into the thorax, while the legs are long and slender. The first and highest series culminates in *Apis*, the Honey-bee; and the second, or lower, in *Cicindela*, the Tiger-beetle.

regarding the rank and value of the minor groups. Professor Agassiz extended Leuckart's views in considering the seven grand divisions of the order of Hexapods as suborders. In 1863 (How to Observe and Collect Insects, Maine Scientific Survey, and Synthetic Types of Insects, Boston Journal of Natural History), we proposed a new classification of these suborders, by which they are thrown into two main groups headed by the Hymenoptera and Coleoptera respectively. These two groups, as represented in the diagram, are nearly equivalent in value, and stand in a somewhat parallel relation. There is nothing like a linear series in the animal kingdom, but rather a net-work. The higher series of suborders form more of a linear series than the lower series, so that in the diagram the Neuroptera, Orthoptera, Hemiptera, and Coleoptera form a more broken series than the Hymenoptera, Lepidoptera, and Diptera. A Bee, Butterfly, and House-fly are much more closely allied to each other than a Beetle, a Squash-bug, a Grasshopper, and a Dragon-fly are among themselves. The Neuroptera are the most independent, and stand at the bottom of and between the two series, though by the Orthoptera they are very intimately linked with the Hemiptera and Coleoptera.

TABULAR VIEW of the principal Entomological Systems proposed since the time of Ray.

Ray, 1705.	Linnæus, 1735.	Fabricius, 1775.	Fabricius, 1799.	Latreille, 1796.	Agassiz, 1849.	Packard, 1863.	Dana, 1864.
Metamorphota. (Coleoptera, Aneloptera, Diptera, Tetraptera). *Ametamorphota* (Hexapoda).	Orders 1–6. Coleoptera, Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera. Order 7. Aptera (six-footed).	Orders 1. Eleuterata. 2. Ulonata. 3. Synistata (in part). (4. Agonata= Crustacea). 5. Unogata (in part). 6. Glossata. 7. Rhyngota. 8. Antliata.	Classes 1–5. Eleuterata, Ulonata, Synistata, Piezata, Odonata. Classes 11–13. Glossata, Rhyngota, Antliata.	Orders 1–10. Coleoptera, Orthoptera, Hemiptera, Neuroptera, Hymenoptera, Lepidoptera, Diptera, Suctoria, Thysanura, Parasita.	Suborders 1–7. Lepidoptera, Diptera, Hemiptera, Hymenoptera, Orthoptera, Coleoptera, Neuroptera.	Suborders 1–7. Hymenoptera, Lepidoptera, Diptera, Coleoptera, Hemiptera, Orthoptera, Neuroptera.	1. *Ctenopters.* Hymenoptera, Diptera, Aphaniptera, Lepidoptera, Homoptera, Trichoptera, Neuroptera. 2. *Elytropters.* Coleoptera, Hemiptera, Orthoptera. 3. *Thysanures.*
Ametamorphota polypoda (in part).	Order 7 (in pt.) Aptera (with numerous feet)	Order 5. Unogata (in part).	Class 6. Mitosata.	Order 14. Myriapoda.	*Arachnida.* Suborders 1–2. Araneæ, Acari.	*Arachnida.* Suborders 1–3. Araneæ, Scorpions, Acarina.	*Arachnida.* Suborders 1–3. Araneoids, Scorpionoids, Acaroids.
Ametamorphota octopoda.	Order 7 (in pt.) Aptera (with 8—14 feet).	Order 5. Unogata (in part).	Class 7. Unogata.	Order 11. Acephala.	*Myriapoda.*	*Myriapoda.* Suborders 1–2. Chilopoda, Chilognatha.	*Myriapoda.* Suborders 1–2. Chilopods, Diplopods.

HYMENOPTERA.

The Bees, Wasps, Saw-flies, Ants, and other members of this suborder differ from all other insects in having, in the higher and more typical forms, the basal joint of the abdomen thrown forward upon and intimately united with the thorax. The head is large, with large compound eyes, and three ocelli. The mouth-parts are well developed both for biting, and feeding on the sweets of plants, the ligula especially, used in lapping nectar, being greatly developed. The other regions of the body are more distinct than in other insects; the wings are small but powerful, with comparatively few and somewhat irregular veins, adapted for powerful and long-sustained flights; and the genital appendages retracted, except in the Ichneumon parasites and Saw-flies, within the body, are in the female modified into a sting.

The transformations of this suborder are the most complete of all insects; the larvæ in their general form are more unlike the adult insects than in any other suborder, while the pupæ, on the other hand, most clearly approximate to the imago. The larvæ are short, cylindrical, footless (excepting the young of the Saw-flies, the lowest family, which are provided with abdominal legs like Lepidopterous larvæ), worm-like grubs, which are helpless, and have to be fed by the prevision of the parent. The pupa has the limbs free, and is generally contained in a thin silken cocoon; that of the Saw-flies, however, being thick.

The Hymenoptera exhibit, according to Professor Dana, the *normal size* of the insect-type. "This archetypic size is be-

NOTE to page 106.—Ray divided the Hexapods into *Coleoptera* and *Aneloptera*, the latter division embracing all the other suborders except the Coleoptera. His *Ametamorphota Hexapoda* contained the wingless hexapoda; while the *Ametamorphota polypoda* comprise the Myriapods, and the *A. octopoda* the Arachnids. Linnæus' *Aptera* (with numerous feet) are equivalent to the Myriapods, and his *Aptera* (with 8–14 feet) to the Arachnids. In Fabricius' system the *Eleutherata* are equivalent to the Coleoptera; the *Ulonata* to the Orthoptera; the *Synistata* to the Neuroptera; the *Piezata* to the Hymenoptera; the *Odonata* to the Libellulidæ; the *Glossata* to the Lepidoptera; the *Rhyngota* to the Hemiptera; the *Antliata* to the Diptera. The *Mitosata* are the Myriapods, and the *Unogata*, the Arachnids. In Latreille's system the *Suctoria*, or Fleas, are now referred to the Diptera; the Parasita or Lice, to the Hemiptera, and the *Thysanura* to the Neuroptera.

tween eight and twelve lines (or twelfths of an inch) in length, and two and a half and three lines in breadth." This size is probably a smaller average than in any other suborder; thus the Hymenoptera while being the most cephalized, consequently comprise the most compactly moulded insectean forms.

Besides these structural characters, as animals, endowed with instincts and a kind of reason differing, perhaps, *only in degree* from that of man, these insects outrank all other Articulates. In the unusual differentiation of the individual into males and females, and, generally sterile workers, with a farther dimorphism of these three sexual forms, such as Huber has noticed in the Humble-bee, and a consequent subdivision of labor among them; in dwelling in large colonies, thus involving new and intricate relations with other insects (such as Aphides, ant-hill-inhabiting beetles, and the peculiar bee-parasites); their wonderful instincts, their living principally on the sweets and pollen of flowers, and not being essentially carnivorous (*i.e.* seizing their prey like the Tiger-beetle) in their habits, as are a large proportion of the other suborders, with the exception of Lepidoptera; and in their relation to man as a domestic animal, subservient to his wants,—the Bees, and Hymenoptera in general, possess a combination of characters which are not found existing in any other suborder of insects, and which rank them first and highest in the insect series.

The body-wall of the Hymenoptera is unusually dense and hard, smooth and highly polished, and either naked, or covered with hair as in a large proportion of the bees. The head is large, not much smaller than the thorax, and its front is vertical. The antennæ are short, filiform, often geniculate, very rarely pectinated. The mandibles are large, stout, toothed, and the maxillæ are well developed into their three subdivisions, the palpi being usually six-jointed; the labial palpi are usually four-jointed, and the prolongation of the under lip, or ligula, is highly developed, being furnished with a secondary pair of palpi, the paraglossæ, while in the pollen-gathering species the ligula is of great length, and thus answers much the same purpose as the spiral tongue (maxillæ) of the Lepidoptera.

Réaumur states that the Bee does not suck up the liquid sweets, but laps them up with its long slender hairy tongue.

"Even in the drop of honey the bee bends the end of its tongue about, and lengthens and shortens it successively, and, indeed, withdraws it from moment to moment." The liquid passes along the upper surface of the pilose tongue, which is withdrawn between its sheaths, the palpi and maxillæ, and thus "conveys and deposits the liquid with which it is charged within a sort of channel, formed by the upper surface of the tongue and the sheaths which fold over it, by which the liquid is conveyed to the mouth." (Shuckard.)

The thorax forms a rounded compact oval mass, with the prothorax and metathorax very small, the mesothorax being large, and also the propodeum, to which the pedicel of the abdomen is attached. The pleurites are large and bulging, while the sternum is minute. The coxæ and trochantines are large, and quite free from the thorax; and the trochanters are small, while the rather slender legs are subject to great modifications, as they are devoted to so many different uses by these insects; thus, in the Sand-wasps they are strongly bristled for the purpose of digging, and in the Bees, the basal joint of the tarsi is much enlarged for carrying honey.

"The manner in which the bee conveys either the pollen, or other material it purposes carrying home, to the posterior legs, or venter, which is to bear it, is very curious. The rapidity of the motion of its legs is then very great; so great, indeed, as to make it very difficult to follow them; but it seems first to collect its material gradually with its mandibles, from which the anterior tarsi gather it, and that on each side passes successively the grains of which it consists to the intermediate legs, by multiplicated scrapings and twistings of the limbs; this, then, passes it on by similar manœuvres, and deposits it, according to the nature of the bee, upon the posterior tibiæ and tarsi, or upon the under side of the abdomen. The evidence of this process is speedily manifested by the posterior legs gradually exhibiting an increasing pellet of pollen. Thus, for this purpose, all the legs of the bees are more or less covered with hair. It is the mandibles which are chiefly used in their boring or excavating operations, applying their hands, or anterior tarsi, only to clear their way; but by the constructive, or artisan bees, they are used both in their building and

mining operations, and are worked like trowels to collect moist clay, and to apply it to the masonry of their habitations." (Shuckard.)

The four wings are present, except in rare instances. They are small; the hinder pair long, narrow, ovate, lanceolate. The costal edge of the fore-wing (Fig. 29), is generally straight, becoming a little curved towards the apex, which is obtusely subrectangular; the outer edge is bent at right angles, while the inner edge of the wing is long and straight. The veins are often difficult to trace, as in the outer half of the wing they break up into a system of net-veins, which are few in number, yet the continuations of the subcostal, median, and submedian veins can be distinguished after careful study.

In some low *Ichneumonidæ*, the *Proctotrupidæ*, and *Chalcididæ*, the veins show a tendency to become obsolete, only the simple subcostal vein remaining; and in *Pteratomus*, the veins are entirely obliterated, and the linear feather-like wings are in one pair fissured, reminding us of the Plume-moths, *Pterophorus*.

The abdomen is composed in the larva state of ten segments, but in the adult stinging Hymenoptera, of six complete segments in the females, and seven in the males; while in the lower families the number varies, having in the *Tenthredinidæ*, eight tergites on the upper side and six sternites on the lower side. The remaining segments are, during the transformations of the insect, aborted and withdrawn within the body. The ovipositor and corresponding parts in the male have been described on pp. 14–18.

The nervous system consists in the larvæ of eleven ganglia, in the adult five or six of these remain as abdominal ganglia, while the remainder, excluding the cephalic ganglia, are placed in two groups in the thorax. The cerebral ganglia are well developed, evincing the high intellectual qualities necessary in presiding over organs with such different uses as the simple and compound eyes, the antennæ, and lingua and palpi, and mandibles, especially in those sociable species which build complete nests.

The digestive system, in those bees which sip up their food, consists, besides the external mouth-parts, of a "long œsoph-

agus which dilates into a thin-walled sucking stomach," which in the *Apiariæ* and *Vespidæ* may be simply a lateral fold, or, as in many *Crabronidæ*, "attached solely by a short and narrow peduncle." In *Formica*, *Cynips*, *Leucospis*, and *Xyphidria* there is a globular uncurved callous gizzard, which is enveloped by the base of the stomach, according to Siebold, who also states that "those Hymenoptera which are engaged during a long and active life in labors for the raising and support of their young, have a pretty long and flexuous stomach and intestine, and the first has, usually, many constrictions;" while the *Cynipidæ*, *Ichneumonidæ*, and *Tenthredinidæ*, which take no care of their young, have only a short small stomach and intestine. The salivary glands consist of two rather short ramified tufts, often contained entirely in the head.

The tracheæ consist, as in other insects, of two main branches, from which numerous transverse anastomosing branches are given off, with numerous vesicular dilatations. Two such vesicles of immense volume are situated at the base of the abdomen, which according to Hunter and Newport "serve chiefly to enable the insect to alter its specific gravity at pleasure during flight, and thus diminish the muscular exertion required during these movements."

The urinary vessels are very numerous in the Hymenoptera; they are usually short and surround the pylorus in numbers of from twenty to one hundred and fifty.

The two poison glands (Fig. 54, *h*, *g*) are composed of long ramose tubes, resembling the salivary glands in their minute structure. The poison is poured from these into a pyriform sac lodged near the base of the sting, which is provided with a peculiar muscular apparatus for its sudden extension and withdrawal. The poison, in the Ants, Bees, and Wasps, consists, according to Will, of "formic acid, and a whitish, fatty, sharp residuum, the former being the poisonous substance." (Burnett.)

Whether the wax-secreting apparatus consists of special glands (as Milne-Edwards supposes) or not, as Dufour, Siebold, and others contend, is not yet a settled question. Siebold, the eminent German physiologist, from whose work on the anatomy of Invertebrata we have drawn so largely, suggests that the

wax "is produced by an exudation from the thin membranes which connect the different parts of the legs. Moreover, many other Insects (*Coccidæ* and *Aphidæ*, *Flata*, etc.) have secretory products which transude through the skin without the existence of any special glandular apparatus, and which are hardened by the air like wax. These products are usually whitish, pulverulent, filamentous, or flocculent substances, which catch upon the surface of bodies." He also states that there are no such glands (as are supposed by some to secrete this substance) in the "bee-workers; but if certain Andrenidæ are examined, there will be found, on each side of their posterior tibiæ, a small pyriform follicle with an excretory duct, and which secretes an oily substance." Gerstæcker states that the wax is produced on the under side of the abdominal segments. It is formed by chemical changes in the food during the process of nutrition.

The honey is elaborated by an unknown chemical process, from the food contained in the proventriculus, or crop, and which is regurgitated into the honey-cells.

The ovaries consist of many-chambered, four, six, or a hundred, short tubes. "The *receptacula seminis* is nearly always simple, round or ovoid, and necked, and is prolonged into a usually short seminal duct." The *glandula appendicularis* consists of a bifurcate tube which opens into the *ductus seminalis*, and only rarely into the *capsula seminalis* itself.

In the *Tenthredinidæ*, "this apparatus is formed on a different type; the seminal vesicle is a simple diverticulum of the vagina, and more or less distinct from it, besides it is deficient in the accessory gland. The copulatory pouch is absent in all the Hymenoptera, as are also the sebaceous glands with those females which have a sting and a poison gland," while in other insects the sebaceous glands are present, and it would be naturally inferred, therefore, that the two are homologous, but modified for diverse functions.

The two testes of the male are "composed of long follicles, fasciculate and surrounded, together with a portion of the torose deferent canal, by a common envelope; but more commonly the two testes are contained in a capsule situated on the median line of the body." (Siebold.)

The eggs are usually long, cylindrical, and slightly curved in

the Bees; in the Wasps they are more globular, and affixed by their smaller somewhat pedicelled end to the side, near the bottom of the cell in which they are laid. The eggs of the lower families tend to assume a spherical form. The eggs of different species of *Bombus* present no appreciable differences.

The larvæ of the Bees and Wasps, especially the social species, which live surrounded by their food, are of a very persistent form, the various genera differing but slightly, while the species can scarcely be separated. Such we have found to be the case in the Bees and Wasps (*Vespidæ*) and Fossorial Wasps. The sexes of the species with a very thin tegument, such as *Apis*, *Bombus*, and *Vespa*, can be quite easily distinguished, as the rudiments of the genital armor can be seen through.

The Hymenoptera are mostly confined to the warmer and temperate regions of the earth; as we approach the poles, the Bees disappear, with the exception of *Bombus*, and perhaps its parasite *Apathus*; a species of *Vespa* is found on the Labrador coast, which has a climate like that of Greenland. No fossorial species of Wasps are known to us to occur in the arctic regions, while a few species of Ants, and several *Chalcididæ* and *Ichneumonidæ* are not uncommon in Northern Labrador and Greenland. Our alpine summits, particularly that of Mt. Washington, reproduces the features of Northern Labrador and Greenland as regards its Hymenopterous fauna. The tropics are, however, the home of the Hymenoptera, and especially of the Bees.

There are estimated to be about twenty-five thousand living species of this suborder, and this is probably a much smaller number than are yet to be discovered.

In geological history, the Hymenoptera do not date far back compared with the Neuroptera and Orthoptera, and even the Coleoptera. Indeed they were among the last to appear upon the earth's surface. The lower forms, so far as the scanty records show, appeared first in the Jura formation; the Ants appear in the Tertiary period, especially in amber.

As we have noticed before, the Hymenoptera are more purely terrestrial than any other insects. None are known to be aquatic in the early stages, and only two genera have been found

swimming in the adult state on the surface of pools, and they are the low, minute, degraded Proctotrupids, *Prestwichia natans* and *Polynema natans* described by Mr. Lubbock. The Hymenoptera do not imitate or mimic the forms of other insects, but, on the contrary, their forms are extensively copied in the Lepidoptera, and especially the Diptera. A partial exception to this law is seen in the antennæ of the Australian genus *Thaumatosoma*, where they are long and slender, and knobbed as in the butterfly, and also in *Tetralonia mirabilis* of Smith, from Brazil.

The Hymenoptera, also, show their superiority to all other insects in the form of their degraded wingless species, such as *Pezomachus*, the workers of *Formica* and the female of *Mutilla*. In these forms we have no striking resemblances to lower orders and suborders, but a strong adherence to their own Hymenopterous characters. Again; in the degradational winged forms, we rarely find the antennæ pectinated; a common occurrence in the lower suborders. In a low species of the *Apiariæ*, *Lamprocolletes cladocerus*, from Australia,—that land of anomalies,—the antennæ are pectinated. This, Mr. F. Smith, the best living authority on this suborder, says, "is certainly the most remarkable bee that I have seen, and the only instance, to my knowledge, of a bee having pectinated antennæ; such an occurrence, indeed, in the Aculeate Hymenoptera is only known in two or three instances, as in *Psammotherma flabellata* amongst the *Mutillidæ*, and again in *Ctenocerus Klugii* in the *Pompilidæ;* there is also a modification of it in one or two other species of *Pompilidæ*." Among the *Tenthredinidæ*, the male *Lophyrus* has well-pectinated antennæ, as also has *Cladomacra macropus* of Smith, from New Guinea and Celebes.

The wings of perhaps the most degraded Hymenoptera, the *Proctotrupidæ*, are rarely fissured; when this occurs, as in *Pteratomus Putnamii*, they somewhat resemble those of *Pterophorus*, the lowest moth. It is extremely rare that the compound eyes are replaced by stemmata, or simple eyes; in but one instance, the genus *Anthophorabia*, are the eyes in the male sex reduced to a simple ocellus. This species lives in the darkness of the cells of Anthophora.

By reason of the permanence of the type, due to the high rank of these insects, the generic and specific characters are founded on very slight differences, so that these insects, and particularly the two higher families, the Wasps (*Vespidæ*) and Bees (*Apiariæ*) are the most difficult insects to study. The easiest characters for the recognition of the genera, lie in the venation of the wings; though in the fossorial families the legs vary greatly. The best specific characters lie in the sculpturing and style of coloration, but the spots and markings are apt to vary greatly. The great differences between the sexes are liable to mislead the student, and hence large collections are indispensable for their proper study. Bees act as "marriage priests" in the fertilization of plants, conveying pollen from flower to flower, and thus insuring the formation of the fruit. It is said that many plants could not be fertilized without the interposition of Bees.

Their interesting habits deserve long and patient study; it is for their observations on the insects of this suborder that the names of Réaumur, the two Hubers, and Latreille will be ever held in special remembrance.

Most Hymenoptera love the sun, and they may be caught while flying about flowers. The nests of bees, wasps, and ants should be sought for and the entire colony captured, together with the parasites. The hairy species should be pinned while in the net, and the naked ones can be put in the collecting-bottle. The larger species may be pinned, like other insects, through the thorax; but the minute Chalcids, etc., should be gummed, like small Coleoptera, upon cards.

The nests of bees and of wasps and ants and the young in various stages of growth should be collected, and in such numbers as to show their different stages of construction, to serve as illustrations of insect architecture.

Apiariæ Latreille (*Apidæ* Leach). This and those families succeeding which are provided with a true sting, were called by Latreille *Hymenoptera Aculeata*. The male antennæ are mostly thirteen-jointed, while in the female they are twelve-jointed. The females (and the workers, when they exist) feed the larvæ, which mostly live in nests or cells.

In the social Bees, besides the normal male and female forms, there are asexual females, whose inner genital organs are partly aborted, though externally only differing in their smaller size from the true females. The male antennæ are longer, tapering more towards the tips, and the eyes of the male approach each other closer over the vertex than in the opposite sex, though these are characters which apply to other Hymenoptera. The mouth-parts are in the higher genera greatly elongated, the labium being long, with the lingua of great length, and the lobes of the maxillæ long and knife-shaped; but these parts, as well as the form of the jaws, are subject to great modifications in the different genera: the labial palpi are four-jointed, and the maxillary palpi are from one to six-jointed. The hind tibia and basal joint of the tarsi are, in the pollen-gathering species, very broad; the tibia is in Apis and Bombus hollowed on the outside, and stiff bristles project over the cavity from each side of the joint, forming the honey-basket (*corbiculum*), on which the "clodden masses of honey and pollen" are conveyed to their nests. In the parasitic genera, such as *Apathus*, the tibia is, on the contrary, convex, rather than concave, though of the usual width; while in *Nomada*, also parasitic, the legs are narrow, the tibia not being dilated.

In *Andrena* and its allies, *Halictus* and *Colletes*, the mouth-parts, especially the tongue, are much shortened, thus affording a passage into the *Vespidæ*. In these genera the tongue is folded back but once between the horny encasement of the maxillæ, but in the higher *Apiariæ* the part formed by the union of the lingua and maxilla is twice bent back, and thus protected by the horny lobes of the maxillæ. The fore-wings have two or three subcostal (cubital) cells.

There are two thousand species of this family. The differences between the larvæ of the various genera of this family are very slight, those of the parasitic species are, however, readily distinguished from their hosts.

The higher *Apiariæ*, comprising the subfamily *Apinæ*, have the ligula long, cylindrical, while the labial palpi have two very long, slender, compressed basal joints, and two short terminal joints.

The genus *Apis* has no terminal spurs on the hind tibiæ,

while the fore-wings have three subcostal (cubital) cells, the middle of which is elongated and acutely wedge-shaped. The eyes in the male are united above; the mouth-parts are nearly aborted, and the hind legs are smooth. In the female there are two paraglossæ on the ligula, and the maxillary palpi are one-jointed. The worker only differs externally from the female in the shorter abdomen.

The larva of the Honey-bee closely resembles that of Bombus, but the body is shorter, broader, and more flattened, while the head is less prominent, and the lateral tubercles along the body are, perhaps, less prominent than in the young Humble-bee, otherwise the two genera are, in the larval state, much alike. In its natural position, the larva lies at the bottom of the cell doubled upon itself.

Though the larvæ are said usually to feed upon pollen, Mr. Desborough states that honey alone is the food of the grub, as he reared 729 larvæ with no other food than honey. But as with the wild bees they may extract honey from the pollen provided for them. He says the matured bees may be observed feeding at night on the bee-bread (pollen). Langstroth (The Hive and Honey-bee), however, states that "pollen is indispensable to the nourishment of the young. It is very rich in the nitrogenous substances which are not contained in the honey."

The Honey-bee, *Apis mellifica*, is now distributed over the civilized world. It was introduced into this country during the seventeenth century, and into South America in 1845 (Gerstæcker). The Italian, or Ligurian, bee is considered by F. Smith as being a climatic variety.

The cultivation of the Honey-bee is rapidly increasing in this country, but the German Bee-masters have made the most progress in theoretical and practical Bee-culture. Convenient hives are now constructed by which all the operations of the bees can be observed at leisure. Gerstæcker thus sums up the habits of the Honey-bee: A fertilized queen which, with a few workers, has wintered over, lays its eggs in the spring first in the worker, and afterwards, at a later period, in the drone-cells (both arranged in two perpendicular rows of cells). Early in summer, the workers construct the larger flask-shaped queen-

cells, which are placed on the edge of the comb, and in these the queen-larvæ are fed with rich and choice nourishment. As soon as the first of the new brood of queens is excluded from its cell, which it indicates by a peculiar buzzing noise, it deserts the old queen, carrying away with it a part of the swarm, and thus forms a new colony. The recently excluded queen then takes its marriage flight high in the air with a drone, and on its return undertakes the management of the hive, and the duty of laying eggs. When another queen is disclosed, the same process of forming a new colony goes on. When the supply of young queens is exhausted, the workers fall upon the drones and destroy them without mercy. The first brood of workers live about six weeks in summer, and then give way to a new brood. Mr. J. G. Desborough states that the maximum period of the life of a worker is eight months. The queens are known to live five years, and during their whole life lay more than a million eggs (V. Berlepsch). Langstroth states that "during the height of the breeding season, she will often, under favorable circumstances, lay from 2,000 to 3,000 eggs a day." According to Von Siebold's discovery only the queens' and workers' eggs are fertilized by sperm-cells stored in the *receptaculum seminis*, and these she can fertilize at will, retaining the power for four or five years, as the muscles guarding the duct leading from this sperm-bag are subject to her will. Drone eggs are laid by unfertilized queen-bees, and in some cases even by worker-bees. This last fact has been confirmed by the more recent observations of Mr. Tegetmeier, of London.

Principal Leitch, according to Tegetmeier, has suggested the theory that a worker egg may develop a queen, if transferred into a queen-cell. "It is well known that bees, deprived of their queen, select several worker-eggs, or very young larvæ, for the purpose of rearing queens. The cells in which these eggs are situated are lengthened out and the end turned downward." He suggests that the development into a queen was caused by the increased temperature of the queen-cell, above that of the worker-cells.

But Messrs. F. Smith and Woodbury (Proceedings of the Entomological Society of London, January 2, 1862) support F.

Huber's theory, that the change is due to "the quality as well as quantity of food with which the royal larva is supplied," though Dr. Leitch objects, that it has been by no means conclusively proved "that the so-called royal jelly differs in any respect from the ordinary food supplied to the worker larva;" and Mr. Woodbury cites the experiments of Dzierzon, as quoted by Kleine, "that as Huber, by introducing some royal jelly in cells containing worker-brood, obtained queens, it may be possible to induce bees. to construct royal cells, when the Apiarian prefers to have them, by inserting a small portion of royal jelly in cells containing worker-larvæ." Kleine takes "an unsealed royal cell—which usually contains an excess of royal jelly—and removes from it a portion of the jelly, on the point of a knife or pen, and by placing it on the inner margin of any worker cell, feels confident that the larvæ in them will be reared as queens."

Before these points are settled we must study the habits of the Wild Bees, and of the other social Hymenoptera and White Ants, together with the social Aphides more carefully. Mr. F. W. Putnam pertinently states, "at present I cannot believe that the peculiarity of food, or the structure of the cells, produces a difference of development in Humble-bees, for the larvæ, as has been previously stated, were seen to make their own cells from the pollen paste. Is it not more natural to believe, as has been suggested to me by Professor J. Wyman, that the difference in the development of the eggs is owing to their being laid at various times after impregnation? Thus, if I am right in supposing that the queens are impregnated by the males late in the summer, the eggs, laid soon after, produce the large queen larvæ;* the next set of eggs, laid in the spring, produce the workers, or undeveloped females, while from those deposited still later, male bees are principally developed." (Proceedings of the Essex Institute, Salem, vol. iv, 1864, p. 103.)

Referring to Mr. Putnam's statement that there are both small and large queens (besides the workers), Dr. Gerstæcker infers,

* Dr. Gerstæcker, on the other hand, states that "from the brood-cells of a nest of *Bombus muscorum*, found by him on the 18th of September, there were developed at the end of the same month only workers."

"from the examination of numerous individuals found flying in the spring after hibernation, that these could not be considered as true queens, since their ovaries were only moderately developed, though larger than those of the workers, while in the true queen, captured in the summer, the ovaries were perfectly developed. This corresponds almost entirely to what we find in the wasps, whose spring females have only moderately developed ovaries."

How the Honey-bee builds its cells, and whether they are exactly hexagonal, are questions that have interested the best observers from Maraldi who wrote in 1712, and Réaumur, whose *Memoires* appeared in 1740, down to the present date. Their solution involves not only the closest observation of the insect while at work, but also the shrewdest judgment to explain the facts observed and deduce a legitimate theory. Does the bee intelligently plan her work out beforehand, or does she follow the guidance of what is called *instinct?* Does she construct hexagonal cells which are mathematically exact, or does she vary the proportions of each cell, so that it is perfect only in its general ideal form? Again, in making the cell, is the bee actually capable of making such a cell alone, or is it due to the resultant action of several bees? Professor J. Wyman is of the latter opinion, as he thinks "that if left alone to build a single cell, this would most probably be round. In the cells of *Melipona*, as Huber's plate shows, they are only hexagonal when in contact with the adjoining cells." (Proceedings of the Boston Society of Natural History, x, p. 278, 1866.)

A similar view is that proposed in 1862 by the Rev. Samuel Haughton, in a paper read before the Natural History Society of Dublin, where he says, according to Mr. F. Smith, that the hexagonal form of the cell "may be accounted for simply by the mechanical pressure of the insects against each other during the formation of the cell. In consequence of the instinct that compels them to work with reference to a plane, and of the cylindrical form of the insect's body, the cells must be hexagonal."

Mr. G. R. Waterhouse (Transactions of the Entomological Society of London. Third series, vol. ii, p. 129, 1864) has

proposed what has been called the "circular theory," or what the author himself terms "the principle of working in segments of circles." He contends "that the hexagonal form of the cells of certain bees and wasps may, and does, arise out of this mode of action when under certain conditions; that those conditions are, that the cells are so commenced that their natural circumferences, as the work proceeds, are either simply brought into contact with each other, or that the cells are so placed that the (we will say theoretical) circumferences must intersect. Contact with adjoining cells, then, is an essential condition to bring about the hexagonal form as I have before pointed out (See Proceedings of the Entomological Society, 1858, p. 17); but for this result it is not necessary that a hexagonal cell should be completely surrounded by other cells."

Is not this theory, after all, too mechanical? Is not our bee more of a free agent? Does it not have a *mind* to design its work? Mr. F. Smith, who has devoted years to the study of Hymenoptera, especially the higher forms of this suborder, the Bees and Wasps, replies to both theories of Waterhouse and Haughton, by bringing in the case of the Wasps which also build hexagonal cells, showing that a solitary wasp will build its cells in very regular hexagons. Thus the nest of the solitary Wasp, *Icaria guttatipennis*, "consists of a double row, the number of cells being ten; I now direct your attention to the fact that all the cells are perfectly hexagonal, the exterior planes being as beautifully finished as those in contact with the inner planes of the opposing cells. I have placed a drawing of this nest (Plate 5, Fig. 7) in the box on the table, and I particularly wish you to observe, that the first cell is carried up in a perfectly hexagonal form above the adjoining cells; a proof that, if Wasps never build perfect isolated hexagonal cells, they certainly possess the capability of doing so. The exterior of all the cells, as I before observed, is hexagonal, not cylindrical, until fresh cells are added on the outer side, as was observed to be the case in combs of the Hive-bee, by Mr. Tegetmeier." (Proceedings of the Entomological Society of London. Third series, ii, 1864, p. 135.)

An examination of the cells of three species of *Polistes* (the female of which begins alone in the spring to build her nest,

the cells of which are afterwards greatly increased in number after the first brood of females appear), convinced us that the Wasp begins with the circular cup-shaped form of cell, and when about depositing an egg in it, changes her mode of operating, builds up the edges into a hexagonal form, and carries up the rim of each cell independently to its required height. She thus apparently changes her plan at a certain stage of the work, and is so far a free agent.

Mr. Smith also exhibited a portion of the nest of another wasp, *Tatua Morio* (Plate 5, Fig. 9), that proved to his mind the primary intention of the wasp instinctively to build cells with exactly six sides. The figure represents part of one of the flat floors, on which the foundations of the cells are laid in regular hexagons, instead of beginning in hemispherical cups.

Mr. Smith (p. 141) concludes, "that all hexagonal cells are not constructed upon a circular principle, and that the primary idea of all social bees and wasps is not to produce cylindrical cells with hemispherical bases."

In this connection the following extract from Mr. Smith's remarks is of interest: "It may not be known that in order to expedite the building of honey-combs, it is a common practice with bee-keepers in Germany to furnish hives with artificial foundations for the cells; these consist of sheets of wax, upon which is impressed a series of pyramidal hollows; in fact, the counterpart of a comb built by the bees themselves, entirely deprived of the cell-walls; and it is from such a piece of comb that the casts for the artificial foundations are obtained. A piece of casting of this description I lay before you, and I particularly call your attention (addressing the members of the Entomological Society of London) to the commencement of the outer cells; you will see, in some instances, a single plane of the hexagonal cell commenced, in others two or three are in progress; here you have a ground-plan supplied, or, I may say, the foundations of the habitations ready prepared, upon which the laborers are to raise the walls, and you may see how admirably they have done it. Instinct enables the bee to construct hexagonal cells without teaching, and, we are told, in one undeviating manner. Surely the example before us exhibits an amount of intelligence on the part of the bees in availing them-

selves of such adventitious aid. Must we not henceforth, when speaking of the marvels of the hive or the vespiary, erase from our vocabulary such terms as blind instinct; and must we not cease to stigmatize the bee as a mere machine?"

At the meeting of the same society held Feb. 1, 1864, Mr. F. Smith exhibited a collection of Wasps' nests,—one of *Vespa rufa*, the rest of *V. vulgaris;* they were in various stages of formation, the earliest consisting of only a single cup containing the first egg, others consisting of three or four cups, whilst others again were more complete. The whole had been artificially obtained by Mr. Stone, who tempted the wasps to build by excavating holes in banks and furnishing them with footstalks; in fact, Mr. Stone appeared to possess the power of inducing wasps to build nests of almost any shape he pleased.

But to return to the cell of the Bee. It should first be proved that the cells are not exactly and mathematically perfect hexagons, though sufficiently so for the purpose for which they are used. In the Proceedings of the American Academy of Arts and Sciences, vol. vii, 1866, Professor Wyman has, by a most careful as well as novel and ingenious mode of investigation, proved that the cells are all more or less imperfect, and that a hexagonal cell mathematically exact, does not exist in nature, but only in theory.

The form of the cell is liable to marked variations, chief among which the following may be mentioned, in the author's own words:

"1. The diameters of workers' cells may so vary, that ten of them may have an aggregate deviation from the normal quantity equal to the diameter of a cell. The average variation is a little less than one half that amount, namely, nearly 0.10 inch, in the same number of cells.

"2. The width of the sides varies, and this generally involves a variation of the angles which adjoining sides make with each other, since the sides vary not only in length but in direction.

"3. The variation in the diameters does not depend upon accidental distortion, but upon the manner in which the cell was built.

"4. The relative size of the rhombic faces of the pyramidal base is liable to frequent variation, and this where the cells are not transitional from one kind to another.

"5. When a fourth side exists in the basal pyramid, it may be in consequence of irregularity in the size of the cells, or of incorrect alignment of them on the two sides of the comb."

Sometimes one of the faces is lost, and a new one formed, so that all the basal portion of the cell becomes reversed, as will be seen by reference to Figs. 73 and 74; the first representing the cells when the base is viewed, and the second when looked at perpendicularly to one of the sides. In both figures A indicates the ordinary form of the cell. The whole series of Fig. 74 shows the gradual introduction of the new face, which is seen on the lower border, and the elimination of one of the original faces, which is seen on the upper border. At B, which is intermediate between the two extremes, the four faces consist of two equal rhombs,—one of which is the outgoing and the other the incoming one, and two equal hexagons. B, Fig. 74, represents the sides of the same cell, which, instead of forming three trapeziums, as at A, *a*, *b*, *c*, now form two pentagons, *a*′ and *c*′, and a parallelogram, *b*′. At C, Figs. 73 and 74, the forms are in all respects the reverse of those of A. A and C are symmetrical with each other, and B is symmetrical in itself. No precise number of cells is necessary for the purpose of making this transition, for it may take place in two or three, or extend through a long series, as in Fig. 73.

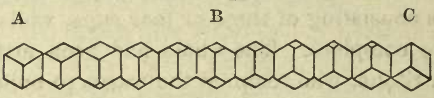


Fig. 73.

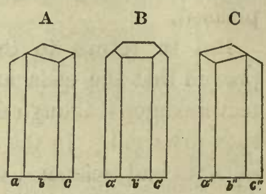


Fig. 74.

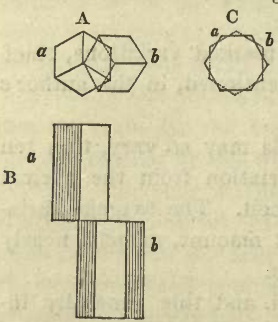


Fig. 75.

"6. Ordinarily, the error of alignment does not amount to more than one or two diameters of a cell. But occasionally

the rows of cells on one side of the comb may deviate from their true direction with regard to those on the other, to the extent of 30°."

"Thus, if a piece of normal comb be held in the position in which it was built, two of the opposite angles of the hexagon, Fig. 75, A, *a*, will be in the same vertical line, and two of the sides will be parallel to this. The same is true of the opposite side of the comb; and thus all the corresponding parts of the cells on the two sides will be parallel. In the deviation we are now noticing, the change is like that represented in A, where the cell *a* is in its true position, while the cell *b*, which is from the opposite side, and is in contact with *a*, varies from it by about 30°. If we look at these two cells in the direction of their sides as at B, the prism *a* will have one of its angles towards the eye, and *b* one of its sides.

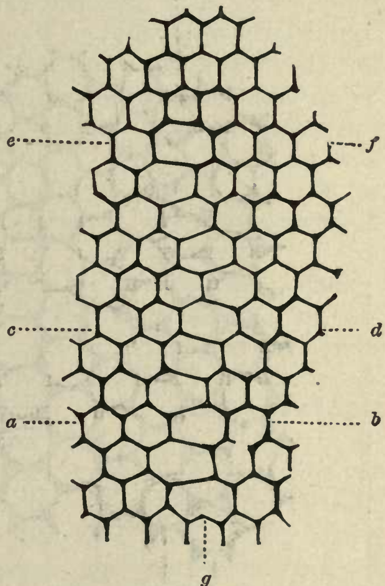


Fig. 76.

In consequence of this deviation and the continual crossing of the rows on opposite sides, the pyramidal base is not made, and the cell is shortened.

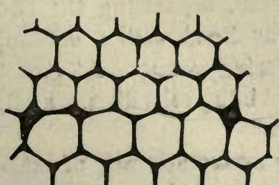


Fig. 77.

"7. In curved or bent combs the cells on the concave side tend to become narrower, while those on the other tend to become broader towards their mouths. In Fig. 76 (this and Figs. 77 and 78 are made from impressions obtained directly from the comb and transferred to wood; they represent the form of the cells exactly), as in the central line of cells, there are a variety of hexagons, each resulting from the union

of two cells, the base being double while the mouth is single. That on the line *a*, *b*, has three sides at one end, united by two long sides with one at the other, and thus two of the opposite sides are not parallel; at *c*, *d*, two sides at

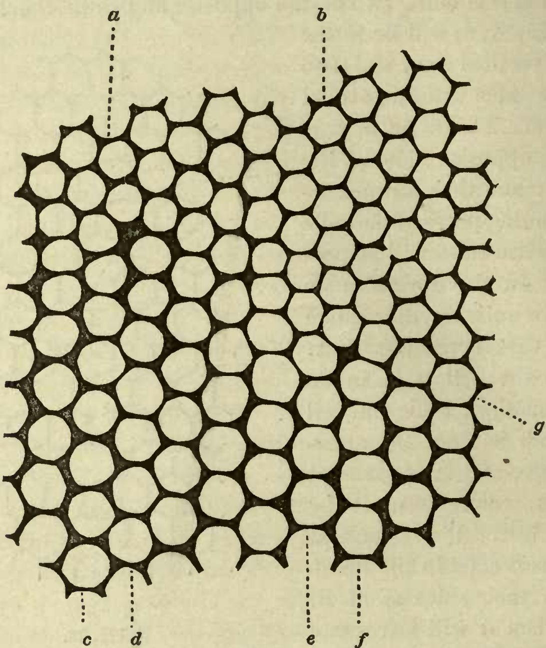


Fig. 78.

either end are united by two long sides, these last being parallel; and at *e*, *f*, the mouth of the compound cell has seven sides. Each has a partition at its base, separating the two originally distinct cells, and each was lined with a cocoon, showing that it had been used for rearing young. At *g*, not only has the partition between the combining cells disappeared, but also three of the sides of each cell."

The bees do not appear to have any systematic way of making a transition from worker to drone cells, which are one-fifth larger than the former. More commonly, they effect it by a gradual alteration of the diameters, thus enlarging a worker into a drone, or narrowing a drone into a worker cell. This alteration is usually made in from four to six rows. In one case

Professor Wyman noticed the transition made with only one cell, as in Fig. 78, but not without destroying the regularity of the two adjoining rows.

"In consequence of the gradual narrowing or widening of the transition cells, the comb tends to become more or less triangular and the cells to become disturbed. The bees counteract this tendency by the occasional intercalation of an additional row, of which two instances are given in Fig. 78, at *a* and *b*, where three rows of worker cells are continuous with two of drone cells, *c*, *d* and *e*, *f;* or, reversing the statement, and supposing the transition, as in the building of the comb, is from worker to drone-cells, a row of the latter is from time to time omitted as the rows *a* and *b;* in this way, the regularity of the comb is preserved."

Honey-cells are formed either by enlarging the ordinary brood-cells, or adding them to others often larger, or by constructing a new comb, devoted entirely to the storing of honey. "While the cells of this last are built unequivocally in accordance with the hexagonal type, they exhibit a range of variation from it which almost defies description."

No Ichneumon-flies are known to attack the larva of the Honey-bee, nor in fact, with few exceptions, any of the wild bees, owing, probably, to the difficulty of their gaining access to them, since *Anomalon vesparum* has been reared from the cells of wasps which are more exposed than those of bees. But the Honey, as well as the wild bees, are afflicted by a peculiar assemblage of insect-parasites, some of which have the most remarkable habits. The most formidable pest of the Hive-bee is the Bee Fly, *Phora incrassata*, which in Europe sometimes produces the well-known disease called "foul-brood." The Bee-louse, *Braula cæca*, is, in Europe, sometimes troublesome to the adult bee, while *Trichodes apiarius*, a beetle, devours the larvæ. The larvæ of *Meloë* and *Stylops* are known in Europe to infest the Honey-bee, and among the low intestinal worms Assmus enumerates *Gordius subbifurcus* which infests the drones of the Honey-bee as well as other insects. Professor Siebold has also described *Mermis albicans*, which is a similar kind of hair-worm, from two to five inches long, and whitish in color. This worm is also found, strangely

enough, only in the drones, though it is the workers which frequent watery places (where the worm deposits its eggs) to appease their thirst. The Wax-moths, *Galleria cereana* and *Achroia alvearia*, do much harm by consuming the wax and thus breaking down the cells, and by filling the hive with their webs.*

The genus *Apis* is indigenous in South America, though the Honey-bee has been extensively introduced into the West Indies. Our Honey-bee is replaced in the tropics by the stingless, minute bees, which store up honey and live in far more numerous colonies. The cells of *Melipona* are hexagonal, nearly approaching in regularity those of the Hive-bee, while the honey-cells are irregular, much larger cavities, which hold about one-half as much honey as a cell of the Humble-bee. From a paper on the Brazilian Honey-bees, read by Mr. F. Smith before the Entomological Society of London, March, 1863, he states that the *Meliponas* are small insects, having *wings shorter than the abdomen*, the latter being very convex and oblong; their mandibles never being dentate; while the *Trigonas* have the wings more ample, and *longer than the abdomen*, which is short, somewhat triangular, while the mandibles are serrated, denticulate, or sometimes edentate. The *Meliponas* are restricted to the new world, while *Trigona* extends into Africa, India, and Australasia.

"All these bees are honey gatherers, but the honey collected by the different species varies greatly in quality: from the nests of some it is excellent; from others, worthless. The honey of the species '*Mombuca*' is said to be black and sour, the quality being dependent on species of flowers from which the honey is collected. This great difference in the honey of the various species is apparently confirmatory of the fact that each species confines itself to particular flowers, never visiting any other kind. The different relative length of the tongue in

*EXPLANATION OF PLATE 2. Parasites of the Honey-bee. Fig. 1, *Phora incrassata*; Fig. 2, pupa; Fig. 3, larva. Fig. 4, *Braula cæca*; Fig. 5, larva. Fig. 6, *Trichodes apiarius*: *a*, larva; *b*, pupa. Fig. 7, *Meloë angusticollis*; Fig. 8, freshly hatched larva; Fig. 9, second stage of larva; Fig. 10, first stage of semi-pupa; Fig. 11, pupa. Fig. 12, *Stylops Childreni* in the body of a wild bee, Andrena; Fig. 13, top view of the same removed from its host; Fig. 14, male of the same; *a*, side view. Fig. 15, *Mucor mellitophorus*, a parasitic fungus. Fig. 16, unknown larva found in nest of Humble-bee. Descriptions of the insect parasites will be given beyond.

the species is also confirmatory of the same supposition; indeed, the great diversity in this respect observable in these bees, appears to me to be analogous to a similar diversity in the length of the bills of humming-birds, which, it is well known, are always adapted for reaching the nectaries of the particular flowers which they usually frequent."

In regard to the immense numbers of individuals in a colony, Mr. Stretch, who collected them at Panama, "found a nest several feet in length in the hollow of a tree, containing thousands of individuals, their numbers being, as he informs me, apparently countless.

"Gardner, in his travels, gives a list of such species (of Melipona) as he met in the provinces of Piauhy and Goyaz, where he found them numerous; in every house, he says, 'you find the honey of these bees;' many species, he tells us, build in the hollow trunks of trees, others in banks; some suspend their nests from branches of trees, whilst one species constructs its nest of clay, it being of large size; the honey of this species, he says, is very good." (Smith.)

In a nest of *Trigona carbonaria* from Eastern Australia, Smith, of the British Museum, found from 400 to 500 dead workers crammed in the spaces between the combs, but he did not find a female among them. The combs are arranged precisely similar to those of the common wasp. The number of honey-pots, which are placed at the foot of the nest, amounted to 250.

Smith inclines to the opinion that the hive of Trigona contains several prolific females; "the accounts given of the multitudes inhabiting some nests is too great, I think, to render it possible that one female could produce them all. Mr. Stretch described a hive that he saw, occupying the interior of a decaying tree, that measured six feet in length, and the multitude of bees he compared to a black cloud. M. Guerin found six females in a nest of *Melipona fulvipes*."

Hill states, in Gosse's Naturalist's Sojourn in Jamaica, "that the wax of these bees [Trigona] is very unctuous and dark colored, but susceptible of being whitened by bleaching. The honey is stored in clusters of cups, about the size of pigeon's eggs, at the bottom of the hive, and always from the

brood-cells. The brood-cells are hexagonal; they are not deep, and the young ones, when ready to burst their casement, just fill the whole cavity. The mother bee is lighter in color than the other bees, and elongated at the abdomen to double their length." Smith also states that the female of this genus has the abdomen greatly distended, reminding one of the gravid female of the White Ant. (Smith, Proc. Ent. Soc., London, Dec. 7, 1863.)

In North America, our nearest ally, as regards its habits, of the true Honey-bee, is the Humble-bee (*Bombus*), of which over forty species are known to inhabit North America.

The economy of the Humble-bee is thus: the queen awakens in early spring from her winter's sleep beneath the leaves or moss, or in deserted nests, and selects a nesting-place generally in an abandoned nest of a field-mouse, or beneath a stump or sod, and "immediately," according to Mr. F. W. Putnam, "collects a small amount of pollen mixed with honey, and in this deposits from seven to fourteen eggs, gradually adding to the pollen mass until the first brood is hatched. She does not wait, however, for one brood to be hatched before laying the eggs of another; but, as soon as food enough has been collected, she lays the eggs for a second. The eggs [Plate 4, Fig. 2] are laid, in contact with each other, in one cavity of the mass of pollen, with a part of which they are slightly covered. They are very soon developed; in fact, the lines are nowhere distinctly drawn between the egg and the larva, the larva and pupa, and again between the latter and the imago; a perfect series, showing this gradual transformation of the young to the imago, can be found in almost every nest.

"As soon as the larvæ are capable of motion and commence feeding, they eat the pollen by which they are surrounded, and, gradually separating, push their way in various directions. Eating as they move, and increasing in size quite rapidly, they soon make large cavities in the pollen mass. When they have attained their full size, they spin a silken wall about them, which is strengthened by the old bees covering it with a thin layer of wax, which soon becomes hard and tough, thus forming a cell. [Plate 4, Figs. 1, 2.] The larvæ now gradually attain the pupa stage, and remain inactive until their full devel-

opment. They then cut their way out, and are ready to assume their duties as workers, small females, males or queens.

"It is apparent that the irregular disposition of the cells is due to their being constructed so peculiarly by the larvæ. After the first brood, composed of workers, has come forth, the queen bee devotes her time principally to her duties at home, the workers supplying the colony with honey and pollen. As the queen continues prolific, more workers are added, and the nest is rapidly enlarged.

"About the middle of summer eggs are deposited which produce both small females and males." . . . "All eggs laid after the last of July produce the large females, or queens; and, the males being still in the nest, it is presumed that the queens are impregnated at this time, as, on the approach of cold weather, all except the queens, of which there are several in each nest, die." (Putnam, Com. Essex Inst., vol. iv, p. 98, 1864.)

Besides Apathus, the larvæ of various moths consume the honey and waxen cells; the two-winged flies, Volucella and Conops, and the larvæ of what is either an Anthomyia or Tachina-like fly; several species of Anthrax, the Coleopterous Anobium paniceum of Europe, Meloë, Stylops, and Antherophagus ochraceus are parasitic on Humble-bees.*

The habits of the genus *Apathus* are not clearly known, but they are supposed to prey, in the larva state, upon the larvæ of Bombus, being found in their nests; their habits, so far as known, ally them with Nomada. The species are distinguished by the tibiæ being convex, instead of concave, as in Bombus, while the mandibles of the females are acute, triangular, bidentate, being spatulate and three-toothed in Bombus, and they have no pollenigerous organs. There are males and females only, as in all the remaining genera of the family. *Apathus Ashtonii* (Plate 3, Fig. 1) is found in the Northern States.

* EXPLANATION OF PLATE 3.—Parasites of the Humble and Leaf-cutter Bees. Fig. 1, *Apathus Ashtonii.* Fig. 2, *Nephopteryx Edmandsii; a*, larva; *b*, pupa. Fig. 3, 3 *a*, *Microgaster nephoptericis*, an Ichneumon parasite of Nephopteryx. Fig. 4, *Antherophagus ochraceus.* Fig. 5, *Anthomyia?* larva; *a*, side view. Fig. 6, Recently hatched larva of *Stylops Childrenii*; *a*, side view. Fig. 7, larva; *a*, pupa of *Anthophorabia megachilis*, a Chalcid parasite on Megachile. Fig. 8, *Pteratomus Putnamii*, an exceedingly minute Proctotrupid fly, supposed to be parasitic on Anthorphorabia megachilis; *a*, a hind wing. Fig. 9, a Mite found in the nests of Humble-bees.

Xylocopa, the Carpenter-bee, is "the largest and most bulky of all known bees," but less hirsute than Bombus, while the basal joint of the labial palpi is almost four times as long as the second; and the maxillary palpi are six-jointed, the mouth-parts being very highly organized. The larva of *X. Virginica* (Plate 4, Fig. 3, adult; Fig. 4, larva; Fig. 5, nest) is slenderer than that of Bombus, the body tapering more rapidly towards each end.

The power of boring the most symmetrical tunnels in solid wood reaches its perfection in the large Virginian Carpenter-bee (*Xylocopa Virginica*). We have received from Mr. James Angus, of West Farms, N. Y., a piece of trellis for a grape-vine, made of pine wood, containing the cells and young in various stages of growth, together with the larvæ and chrysalids of *Anthrax sinuosa* (Plate 4, Fig. 6, larva; Fig. 7, pupa), a species of fly parasitic on the larva of the bee, and which buries its head in its soft body and feeds on its juices.

Mr. Angus thus writes us regarding its habits, under date of July 19: "I asked an intelligent and observing carpenter yesterday, if he knew how long it took the Xylocopa to bore her tunnel. He said he thought she bored about one-quarter of an inch a day. I don't think myself she bores more than one-half inch, if she does that. If I mistake not, it takes her about two days to make her own length at the first start; but this being across the grain of the wood may not be so easily done as the remainder, which runs parallel with it. She always follows the grain of the wood, with the exception of the entrance, which is about her own length. The tunnels run from one to one and a half feet in length. They generally run in opposite directions from the opening, and sometimes other galleries are run above the first, using the same opening. I think they only make new tunnels when old ones are not to be found, and that the same tunnels are used for many years. Some of the old tunnels are very wide. I have found parts of them about an inch in diameter. I think this is caused by rasping off the sides to procure the necessary material for constructing their cells. The partitions are composed of wood-raspings, and some sticky fluid, probably saliva, to make it adhere.

"The tunnels are sometimes taken possession of by other bees and wasps. I think when this is the case, the Xylocopa prefers making a new cell to cleaning out the mud and rubbish of the other species. I frequently find these bees remaining for a long time on the wing close to the opening, and bobbing their heads against the side, as if fanning air into the opening. I have seen them thus employed for twenty minutes. Whether one bee, or more, makes the tunnel, that is, whether they take turns in boring, I cannot say at present. In opening the cells, more than one are generally found, even at this season. About two weeks ago, I found as many as seven, I think, in one." *

The hole is divided by partitions into cells about seven-tenths of an inch long. These partitions are constructed of the dust or chippings made by the bee in eating out her cells, for our active little carpenter is provided with strong cutting jaws, moved by powerful muscles, and on her legs are stiff brushes of hair for cleaning out the tunnel as she descends into the heart of the solid wood. She must throw out the chips she bites off from the sides of the burrow with her hind legs, passing the load of chips backwards out of the cell with her fore-limbs, which she uses as hands.

The partitions are built most elaborately of a single flattened band of chips, which is rolled up into a coil four layers deep. One side, forming the bottom of the cell, is concave, being

* "Since writing the above I have opened one of the new holes of Xylocopa which was commenced between three and four weeks ago, in a pine slat used in the staging of the greenhouse. The dimensions were as follows: Opening fully 3-8 wide; depth 7-16; whole length of tunnel 6 and 5-16 inches. The tunnel branched both ways from the hole. One end, from opening, was 2 and 5-8, containing three cells, two with larva and pollen, the third empty. The other side of the opening, or the rest of the tunnel, was empty, with the exception of the old bee (only one) at work. I think this was the work of one bee, and, as near as I can judge, about twenty-five days' work. Width of tunnel inside at widest 9-16 inch.

For some days this bee has been discharging a great quantity of saw-dust and pollen, which I had collected by placing a vessel under it. It would seem that she had cells constructed also in the opposite side of the hole, and that she removed them to enlarge the tunnel. Among the stuff thrown out, I find a partition of a cell nearly entire.

I have just found a Xylocopa bobbing at one of the holes, and in order to ascertain the depth of the tunnel, and to see whether there were any others in them, I sounded with a pliable rod, and found others in one side, at a depth of five and one half inches; the other side was four inches deep, without bees. The morning was cool, so that the object in bobbing could not be to introduce fresh currents of air, but must have had some relation to those inside. The legs on such occasions are, as I have noticed, loaded with pollen."—American Naturalist, vol. 1, p. 370.

beaten down and smoothed off by the bee. The other side of the partition, forming the top of the cell, is flat and rough.

At the time of opening the burrow, July 8th, the cells contained nearly full-grown larvæ, with some half developed. They were feeding on the masses of pollen, which were as large as a thick kidney-bean, and occupied nearly half the cell. Sapyga repanda is parasitic in the cells of *Xylocopa violacea* of Southern Europe.

The habits and structure of the little *Ceratina* ally it closely with Xylocopa, as it hollows out the stems of plants, and builds in them its cylindrical cells. This bee is oblong in form, with tridentate mandibles, and a short labrum. The maxillary palpi are six-jointed, and the labial palpi are two-jointed. *Ceratina dupla* Say is a common small bright-green smooth-bodied species, which, in the middle of May, according to Dr. Harris' MS. notes, tunnels out the stems of the elder or blackberry, syringa, or any other pithy shrub, excavating them often to a depth of six or seven inches, and even, according to Mr. Haldeman (Harris MS.), bores in acorns. She makes the walls just wide enough to admit her body, and of a depth capable of holding three or four, often five or six cells (Plate 4, Fig. 11). The finely built cells, with their delicate silken walls, are cylindrical and nearly square at each end, though the free end of the last cell is rounded off. They are four and a half tenths of an inch long, and a little over one-third as broad. The bee places them at nearly equal distances apart, the slight interval between them being filled in with dirt.

Dr. T. W. Harris* states that, "May 15, 1832, one female laid its eggs in the hollow of an aster-stalk. Three perfect insects were disclosed from it July 28th." The observations of Mr. Angus, who saw some bees making their cells, May 18th, also confirms this account. The history of our little upholsterer is thus cleared up. Late in the spring she builds her cells, fills them with pollen, and lays one or more eggs upon each one. Thus in about two months the insect completes its transformations; within this period passing through the egg, the larval and chrysalid states, and then, as a bee, living through the winter. Its life thus spans one year.

* According to a note in MSS. deposited in the Library of the Boston Society of Natural History.

The larva (Plate 4, Fig. 10) is longer than that of Megachile, and compared with that of Xylocopa, the different segments are much more convex, giving a serrate outline to the back of the worm. The pupa, or chrysalis, we have found in the cells the last of July. It is white, and three-tenths of an inch long. It differs from that of the Leaf-cutter bee in having four spines on the end of the body, and in having a much longer tongue and maxillæ, both being almost twice as long.

In none of the wild bees are the cells constructed with more nicety than those of our little Ceratina. She bores out with her jaws a long deep well just the size of her body, and then stretches a thin delicate cloth of silk, drawn tight as a drumhead, across each end of her chambers, which she then fills with a mixture of pollen and honey.

Her young are not, in this supposed retreat, entirely free from danger. The most invidious foes enter and attack them. Three species of Ichneumon-flies, two of which belong to the Chalcid family, lay their eggs within the body of the larva, and emerge from the dried larva and pupa skins of the bee, often in great numbers. The smallest parasite, belonging to the genus Anthophorabia (so called from being first known as a parasite on another bee, Anthophora), is a minute species found also abundantly in the tight cells of the Leaf-cutter bee.

The species of *Anthidium*, according to Smith, are gaily marked with yellow bands and spots; the ligula is almost twice as long as the labial palpi, and acutely pointed; the paraglossæ are short, the maxillary palpi are two-jointed, and there are two subcostal cells. The males are longer than the females, with an elongated and stoutly toothed abdominal tip. The female lines her nest, situated in any hole convenient for its purpose, with down from woolly-stemmed plants. They pass the winter in the larva state, and the bees do not appear until mid-summer. The species mostly occur in the old world.

In *Anthophora*, which approaches nearer to Bombus in its plump and hairy body than the two preceding genera, the ligula is twice as long as the labial maxillæ, ending in a bristle-like point; the basal joint of the hind tarsus is thickly hirsute, while the middle tarsus of the males is generally elongated. The species are gregarious, their numerous cells, while indepen-

dent, are crowded together in grassy banks. Species of Melecta are parasitic on them, ovipositing in their cells. The larvæ are infected by the Chalcid flies, Anthophorabia and Monodontomerus, and by a peculiar species of Mite, Heteropus ventricosus, described by Newport. Say has described *Anthophora abrupta* and *A. taurea* from Indiana.

In *Eucera* the antennæ are very long, while the body is still plump and hairy: our more common form in the Middle States is *Eucera maculata* St. Fargeau. The species are likewise gregarious, and, according to Smith, their habits are precisely the same as those of Anthophora.

In *Megachile*, the Leaf-cutter Bee, the head is broad, the body stout, oblong, the ligula is about one-half longer than the labial palpi, being quite stout, while the paraglossæ are short and pointed; the maxillæ are long and sabre-shaped, while their palpi are short and two-jointed. There are two subcostal cells in the fore wing. It is a thick-bodied bee, with a large square head, stout scissor-like jaws, and with a thick mass of dense hairs on the under side of the tail for the purpose of carrying pollen, since it is not provided with a pollen basket as in the Honey and Humble-bees. The larva is broader and flatter than that of Bombus, the raised pleural region is a little more prominent, and the raised, thickened tergal portion of each ring is more prominent than in Bombus.

The Megachile lays its eggs in burrows in the stems of the elder (Plate 4, Fig. 2), which we have received from Mr. James Angus; we have also found them in the hollows of the locust tree. Mr. F. W. Putnam thus speaks of the economy of *M. centuncularis*, our most common species. "My attention was first called, on the 26th of June, to a female busily engaged in bringing pieces of leaf to her cells, which she was building under a board, on the roof of the piazza, directly under my window. Nearly the whole morning was occupied by the bee in bringing pieces of leaf from a rose-bush growing about ten yards from her cells, returning at intervals of a half minute to a minute with the pieces which she carried in such a manner as not to impede her walking when she alighted near her hole. [We give a figure of the Leaf-cutter bee in the act of cutting out a circular piece of a rose-leaf (Plate 4, Fig. 8). She

alights upon the leaf, and in a few seconds swiftly runs her scissors-like jaws around through the leaf, bearing off the piece in her hind legs.] About noon she had probably completed the cell, upon which she had been engaged, as, during the afternoon, she was occupied in bringing pollen, preparatory to laying her single egg in the cell. For about twenty days the bee continued at work, building new cells and supplying them with pollen. . . . On the 28th of July, upon removing the board, it was found that the bee had made thirty cells, arranged in nine rows of unequal length, some being slightly curved to adapt them to the space under the board. The longest row contained six cells, and was two and three-quarters inches in length; the whole leaf-structure being equal to a length of fifteen inches. Upon making an estimate of the pieces of leaf in this structure, it was ascertained that there must have been at least a thousand pieces used. In addition to the labor of making the cells, this bee, unassisted in all her duties, had to collect the requisite amount of pollen (and honey?) for each cell, and lay her eggs therein, when completed. Upon carefully cutting out a portion of one of the cells, a full-grown larva was seen engaged in spinning a slight silken cocoon about the walls of its prison, which were quite hard and smooth on the inside, probably owing to the movements of the larva, and the consequent pressing of the sticky particles to the walls. In a short time the opening made was closed over by a very thin silken web. The cells, measured on the inside of the hard walls, were .35 of an inch in length, and .15 in diameter. The natural attitude of the larva is somewhat curved in its cell, but if straightened, it just equals the inside length of the cell. On the 31st of July, two female bees came out, having cut their way through the sides of their cells." In three other cells "several hundred minute Ichneumons [Anthophorabia megachilis] were seen, which came forth as soon as the cells were opened." (Com. Essex Inst., vol. iv, p. 105, 1864.)

Megachile integer Say MS., according to Dr. Harris (MS. notes), forms its nest of leaves the first of August. This species is twice as large, but closely resembles *Megachile brevis* of Say. The front of the head is covered with dense ochreous

hairs, becoming shorter and black on the vertex. The nest, preserved in the Harris collection, now in the Museum of the Boston Society of Natural History, is made of rose-leaves, and is scarcely distinguishable from that of *M. centuncularis.*

Osmia, the Mason Bee, is another genus of Carpenter or Upholsterer bees. The species are generally bluish, with greenish reflections, with smooth shiny bodies, and the species are of smaller size than in Megachile. The tongue in this genus is three times as long as the labium, tapering from the base to the acute apex, and clothed with short hair.

Mr. F. Smith states that the larva of the English species hatch in eight days after the eggs are laid, feeds ten to twelve days, when it becomes full-grown, then spins a thin silken covering, and remains in an inactive state until the following spring, when it completes its transformations.

The habits of the little Mason-bees are quite varied. They construct their cells in the stems of plants and in rotten posts and trees, or, like Andrena, they burrow in sunny banks. An European species selects snail-shells for its nest, wherein it builds its earthen cells, while other species nidificate under stones. Curtis found two hundred and thirty cocoons of a British species (*Osmia paretina*), placed on the under side of a flat stone, of which one-third were empty. Of the remainder, the most appeared between March and June, males appearing first; thirty-five more bees were developed the following spring. Thus there were three successive broods for three succeeding years, so that these bees lived three years before arriving at maturity.

Mr. G. R. Waterhouse, in the Transactions of the Entomological Society of London, for 1864 (3d series, vol. 2, p. 121), states that the cells of *Osmia leucomelana* "are formed of mud, and each cell is built separately. The female bee, having deposited a small pellet of mud in a sheltered spot between some tufts of grass, immediately commences to excavate a small cavity in its upper surface, scraping the mud away from the centre towards the margin by means of her jaws. A small shallow mud-cup is thus produced. It is rough and uneven on the outer surface, but beautifully smooth on the inner. On witnessing thus much of the work performed, I was struck with

three points. First, the rapidity with which the insect worked; secondly, the tenacity with which she kept her original position whilst excavating; and thirdly, her constantly going over work which had apparently been completed. . . . The lid is excavated and rendered concave on its outer or upper surface, and is convex and rough on its inner surface; and, in fact, is a simple repetition of the first-formed portion of the cell, a part of a hollow sphere."

The largest species of Osmia known to us is a very dark-blue species which seems to be undescribed. We will call it the wood-boring Osmia (*Osmia lignivora*). It is larger than the *Osmia lignaria* of Say, being just half an inch long. The head is much shorter, and less square than in Say's species. The front of the head below the antennæ is clothed with dark hairs, but above and on the thorax with yellowish ochreous hairs. The body is deep blackish blue, with greenish reflections. We are indebted to a lady for specimens of the bees with their cells, which had been excavated in the interior of a maple tree several inches from the bark. The bee had industriously tunnelled out this elaborate burrow (Plate 4, Fig. 12), and, in this respect, resembles the habits of the Carpenter-bee (*Xylocopa*) more closely than any other species of its genus. The tunnel was over three inches long, and about three-tenths of an inch wide. It contracted a little in width between the cell, showing that the bee worked intelligently, and wasted no more of her energies than was absolutely necessary. The burrow contained five cells, each half an inch long, being rather short and broad, with the hinder end rounded, while the opposite end, next to the one adjoining, is cut off squarely. The cell is somewhat jug-shaped, owing to a slight constriction just behind the mouth. The material of which the cell is composed is stout, silken, parchment-like, and very smooth within. The interstices between the cells are filled with rather coarse chippings made by the bee.

The bee cut its way out of the cells in March, and lived for a month afterwards on a diet of honey and water. It eagerly lapped up the drops of water supplied by its keeper, to whom it soon grew accustomed, and seemed to recognize.

The female of *Osmia lignaria* Say MS., according to Dr.

Harris' MS. notes, was found in the perfect state in cocoons within earthen cells under stones, April 15th. The cell she constructs is half an inch long, oval, cylindrical, and contracted slightly into a sort of neck just before the opening for the exit of the bee. From Mr. James Angus I have received the pellets of pollen, about the size of a pea, in which it deposits its eggs; the larvæ were about one-third grown in August.

This species is larger than *Osmia simillima* of Smith, while the male antennæ are much paler, being fuscous. The front of the head is covered with long dense yellow ochreous hairs. The vertex is not of so dark a green as in *O. simillima*, and is covered with coarse punctures. The thorax is heavily clothed with yellow ochreous, thick hairs. The abdomen is yellowish, and much more hairy. The legs are stout, fuscous, with yellowish hairs. Length, thirty-five inches.

Our smallest and most abundant species is the little green *Osmia simillima* of Smith. It builds its little oval, somewhat urn-shaped cells, against the roof of the large deserted galls of the oak-gall fly (Diplolepis confluentus), placing them, in this instance, eleven in number, in two irregular rows, from which the mature bees issue through a hole in the gall (Plate 4,* Fig. 14. From specimens communicated by Mr. F. G. Sanborn). The earthen cells, containing the tough dense cocoons, were arranged irregularly so as to fit the concave vault of the larger gall, which was about two inches in diameter. On emerging from the cell the Osmia cuts out with its powerful jaws an ovate lid, nearly as large as one side of the cell. Both sexes may be found in April and May in the flowers of the willow

*Explanation of Plate 4.—Fig. 1, a cell of the Humble-bee; natural size, with the pollen mass upon the top. Fig. 2, end view of the same mass, showing the three eggs laid in three divisions of the cavity. Fig. 3, *Xylocopa Virginica*, the Carpenter Bee. Fig. 4, the larva of *Xylocopa Virginica*; natural size. Fig. 5, the nest containing the cells of the same, with the partitions and pollen masses, on which the young larva is seen in the act of feeding; natural size. Fig. 6, young larva of *Anthrax sinuosa*; side view. Fig. 7, pupa of *Anthrax sinuosa*, side view; natural size. Fig. 8, the Leaf-cutter Bee (*Megachile*), on a rose leaf, in the act of cutting out a circular piece. Fig. 9, cells of Megachile, in the elder; natural size. Fig. 10, larva of *Ceratina dupla*, the little green Upholsterer Bee; enlarged. Fig. 11, cells of the same in the stem of the elder; natural size. Fig. 12, cells of *Osmia lignivora*, new species, the wood-devouring Mason-bee, excavated in the maple; natural size. Fig. 13, cells of *Osmia simillima*, the common green Mason-bee, built in the deserted gall of the Oak-gall Fly. Fig. 14, a single earthen cell of the same; natural size. Fig. 15, pollen mass, or bee-bread of *Osmia lignaria*; natural size. It is made up of distinct pellets of pollen, which are probably stuck together with saliva.

and fruit trees which blossom later. The antennæ are black, and the green body is covered with fine white hairs, becoming yellowish above.

In the Harris collection are the cells and specimens of *Osmia pacifica* Say, the peaceful Osmia, which, according to the manuscript notes of Dr. Harris, is found in the perfect state in earthen cells (Plate 5, Fig. 2) beneath stones. The cell is oval cylindrical, a little contracted as usual with those of all the species of the genus, thus forming an urn-shaped cell. It is half an inch long, and nearly three-tenths of an inch wide, while the cocoon, which is rather thin, is three-tenths of an inch long.

The following genera, called Cuckoo Bees, are parasitic on other bees, laying their eggs in the cells, or nests, of their host. In *Cœlioxys* the body is stout, and the bee closely mimics its host, Megachile. The ligula is very long, being almost three times the length of the labium, and the paraglossæ are wholly wanting; the maxillary palpi are short, three-jointed, and the abdominal tip of the male is variously toothed. *Cœlioxys octodentata* Say, is abundant late in the summer about flowers. An allied genus, *Melecta*, is parasitic on Anthophora, and *Epeolus* is parasitic on Colletes.

The species of *Nomada* are very numerous; in all, the tongue is long and acute, with paraglossæ about one-fourth as long as the tongue; the maxillary pair of palpi are six-jointed; and there are three subcostal cells. The species in their slender, smooth, gaily colored body resemble the wasps. These Cuckoo-bees lay their eggs in the nests of Andrena and Halictus, and, according to English authors, Panurgus and Eucera, where they may be found in all stages of development corresponding to those of their hosts. The females do not sting severely. The species emit sweet, balmy, or balsamical odors. Shuckard states that these bees should be killed with burning sulphur to preserve their bright colors.

The larvæ differ greatly from those of their hosts, Andrena, the head being much smaller, the body being smoother and rounder, and belonging to a more degraded, lower type. The whole body is more attenuated towards both extremities. The pupa differs from those of any other genus of this family known to us, except Andrena, by having three conspicuous

spines on the upper and posterior edge of the orbit, which are also found in the pupa of Stigmus, a Crabronid genus, and which evidently aid in locomotion. Thus the same law of degradation obtains in these highly organized bee-parasites as in the lower parasitic species, though in a much less marked degree.

From specimens found in the nests of Andrena and Halictus, collected at Salem by Mr. J. H. Emerton, and now in the Museum of the Essex Institute, we have been enabled in great part to clear up the history of this bee. We have found in the nests of Andrena vicina both sexes of *Nomada imbricata* Smith, and several females of *Nomada pulchella* of Smith; and in the cells of Halictus parallelus Say, specimens of *Nomada imbricata.* Both full-grown larvæ and pupæ of different ages, up to the adult Nomada, ready to take leave of its host, were found in the cells of the Andrena vicina. It seems, therefore, that the newly hatched young of Nomada must feed on the pollen mass destined for the Andrena. But there seems to be enough for *both* genera to feed upon, as the young of both host and parasite were found living harmoniously together, and the hosts and their parasites are disclosed both at the same time. Does not this mild sort of parasitism in Nomada throw much light on the probable habits of Apathus, the Humble-bee parasite? It is more than probable that the Apathus larvæ simply eat the food of the Bombus larvæ, and do not attack the larvæ of their hosts. Both Nomada and Apathus in their adult stages live harmoniously with their hosts, and are seen gathering food from the same flowers, and flying about the same nest.

In the second subfamily, *Andrenetæ*, the ligula, or tongue, is for the most part short and broad, and the maxillary palpi have four joints of equal size.

In *Sphecodes* the body is smooth and wasp-like, and in its habit of running and flying in dry sandy places, it resembles Sphex, whence its generic name. The abdomen is generally light red, farther aiding in the resemblance to the *Sphegidæ*. The ligula is short, lancet-shaped, fringed with setæ; the paraglossæ are not so long as the tongue, while the labial palpi are shorter than the paraglossæ, and the maxillæ are broad, lanceolate, with six-jointed palpi. The antennæ of the males are

short and sometimes moniliform. *Sphecodes dichroa* Harris is our most common species. Mr. F. Smith, from direct observation, states that this genus builds cells, though earlier authors have stated that it is parasitic on Halictus and Andrena.

Prosopis is generally yellow on the face, and is "less pubescent than any of the bees." The tongue is broad, subemarginate, the paraglossæ reach a little beyond the tongue; the labial palpi are as long as the tongue, while there are two subcostal cells in the fore wings. Smith states that the genus is not parasitical as formerly supposed, as he has "repeatedly bred them" from cells laid in a regular order in the hollow of bramble stems. Mr. S. Saunders has also raised them in Albania where "they construct their cells in bramble sticks (which they bore in the same manner as *Colletes*) with a thin transparent membrane, calculated for holding semi-liquid honey, which they store up for their young. The species are much attacked by Stylops." Like Sphecodes and Ceratina, this genus, according to Smith, is unprovided with pollenigerous organs. We have several species in this country of which *P. affinis* Smith, and *P. elliptica* Kirby, are found northward. The habits of our species are not known.

Augochlora comprises beautiful shining metallic green species, very commonly met with. The thorax is globose, and the anterior wings have one marginal and three submarginal cells; the first submarginal cell as long as the second and third united. *Augochlora purus* Smith is a small, green, rather common species. Mr. J. H. Emerton has found its nests in Salem, near those of Andrena. The mouth of the hole opened under a stone, and was built up so as to form a tube of sand (Plate 5, Fig. 1). The burrow on the 28th of June was four inches deep.

Andrena is a genus of great extent, and the species are often difficult to distinguish. The lanceolate tongue is moderately long, and the paraglossæ are half as long as the tongue itself, while the six-jointed maxillary palpi are longer than the maxillæ themselves. The wings have three subcostal cells, with the rudiments of a fourth one; the second is squarish, and the third receives a recurrent nervure near the middle. The posterior legs "have a long curled lock upon the trochanter be-

neath, and the anterior upper surface of the femora is clothed with long loose hair, which equally surrounds the whole of the tibiæ." (Shuckard.) The abdomen is banded more or less conspicuously with reddish.

The larva (Fig. 79) is stout and thick, with a head of moderate size, and the mouth-parts are a little shorter than usual, the maxillæ and labium especially. The segments of the body are much more convex (angularly so) than usual, giving a tuberculate outline to the body. It is stouter than that of Halictus, the wings are less convex than in that genus ; while the maxillæ are much stouter and blunter. The pupa is distinguished from the other genera by much the same characters as the imago, except that there are two tubercles on the vertex near the ocelli. From a comparison of all its stages, this genus stands intermediate between those placed above, and Halictus, which, in all its characters, is a more degraded form. The males often differ widely from the other sex, in their broad heads and widely spreading bidentate mandibles.

Fig. 79.

Mr. Emerton has observed the habits of our most common species, *Andrena vicina* Smith, which builds its nest in grassy fields. The burrow is sunken perpendicularly, with short passages leading to the cells, which are slightly inclined downwards and outwards from the main gallery. The walls of the gallery are rough, but the cells are lined with a mucus-like secretion, which, on hardening, looks like the glazing of earthen-ware. In Fig. 80 Mr. Emerton gives us a profile view of natural size of the nest showing the main burrow and the cells leading from it ; the oldest cell, containing the pupa (*a*) is situated nearest the surface, while those containing larvæ (*b*) lie between the pupa and the cell (*e*) containing the pollen mass and egg resting upon it. The most recent cell (*f*) is the deepest down, and contains a freshly deposited pollen mass. At *c* is the beginning of a cell ; *g* is the level of the ground. The bees were seen at work on the 4th of May, at Salem, Mass., digging their holes, one of which was already six inches deep ; and by the 15th, hundreds of holes were observed. On the 28th of May, in unearthing six holes, eight cells were found to contain pol-

len, and two of them a small larva. On the 29th of June six full-grown larvæ were exhumed, and one about half-grown. About the first of August the larva transforms to a pupa, and during the last week of this month the mature bees appear.

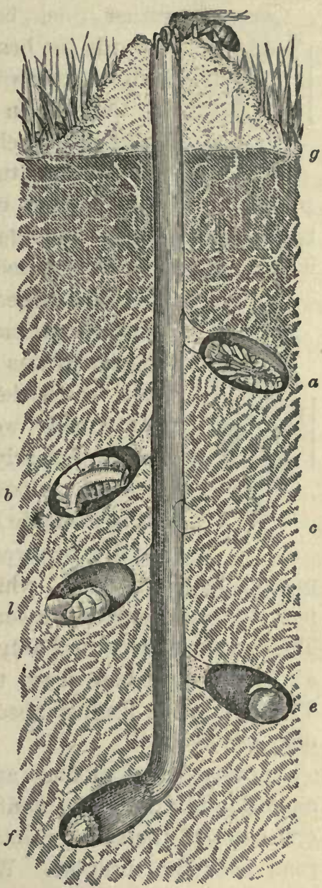


Fig. 80.

In *Halictus*, which is a genus of great extent, the head is transverse, and flattish; the mouth-parts are of moderate length, the tongue being very acute, with acute paraglossæ half the length of the tongue, while the labial palpi are not quite so long as the paraglossæ. There are three subcostal cells in the wings, with the rudiments of a fourth often present, and the second cell is squarish. The abdomen is oblong ovate, with a longitudinal linear furrow on the tip in the female. In the males the body is longer and the antennæ more filiform and slender than usual in this family.

The larvæ are longer, and with more acutely convex segments than in Andrena. The pupæ differ much as the adult bees from Andrena, especially in the shorter mouth-parts.

Halictus parallelus Say excavates cells almost exactly like those of Andrena; but since the bee is smaller, the holes are smaller, though as deep. Mr. Emerton found one nest, in a path, a foot in depth. Another nest, discovered September 9th, was about six inches deep. The cells are in form like those of Andrena, and like them are glazed within. The egg is rather slender and much curved; in form it is long, cylindrical, obtuse at one end, and much smaller at the other. The larva

(Fig. 81) is longer and slenderer, being quite different from the rather broad and flattened larva of Andrena. The body is

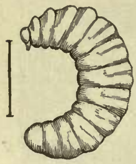


Fig. 81.

rather thick behind, but in front tapers slowly towards the head, which is of moderate size. Its body is somewhat tuberculated, the tubercles aiding the grub in moving about its cell. Its length is .40 of an inch. On the pupa are four quite distinct conical tubercles forming a transverse line just in front of the ocelli; and there are also two larger, longer tubercles, on the outer side of each of which an ocellus is situated. Figure 82 represents the pupa seen from beneath.

Fig. 82.

Search was made for the nests on July 16th, when the ground was very hard for six inches in depth, below which the soil was soft and fine, and over twenty cells were dug out. "The upper cells contained nearly mature pupæ, and the lower ones larvæ of various sizes, the smallest being hardly distinguishable by the naked eye. Each of these small larvæ was in a cell by itself, and situated upon a lump of pollen, which was of the size and shape of a pea, and was found to lessen in size as the larva grew larger. These young were probably the offspring of several females, as four mature bees were found in the hole." (Emerton.) The larva of an English species hatches in ten days after the eggs are laid.

Another brood of bees appeared the middle of September, as on the ninth of that month (1864) Mr. Emerton found several holes of the same species of bee made in a hard gravel road near the turnpike. When opened, they were found to contain several bees with their young. September 2, 1867, the same kind of bee was found in holes, and just ready to leave the cell.

Like Bombus, the females are supposed to hybernate, the males not appearing until late in the season. Like Andrena, these bees suffer from the attacks of Stylops, and according to Shuckard, an Ichneumon preys upon them, while certain species of Cerceris, Philanthus, and Crabro carry them off to store their nests with.

In *Colletes* the females, as Shuckard observes, resemble the workers of the Honey-bee, while there is considerable disparity between the sexes, the males being much smaller, the tongue and maxillæ very short; and the four-jointed labial palpi much shorter than the paraglossæ. There are three subcostal cells, with the rudiments of a fourth. These bees form large colonies, burrowing in the earth eight or ten inches deep, lining their cells "at the farther end with a very thin transparent membranaceous coating, resembling goldbeaters' skin." They thus furnish six or eight cartridge-like cells, covering each with a cap, "like the parchment on a drum-head." Smith, from whom we have been quoting, states that *Miltogramma punctata*, which is a Tachina-like fly, and the Cuckoo-bee, *Epeolus variegatus*, have, in Europe, been reared from their cocoons.

VESPARIÆ Latreille, *Wasps*. In this family, which comprises about 900 species, the body is more attenuated, more cylindrical, with a harder and smoother tegument than in the *Apiariæ*. In the species with densely populated colonies, such as Vespa and Polistes, there are workers which are often very numerous, while in Eumenes and Odynerus, etc., there are only males and females. The antennæ are elbowed, the mandibles are large, stout; the maxillæ and labium of varying length; the maxillary palpi are six-jointed; while on the labial palpi, which are four-jointed, there are well-developed paraglossæ. The prothorax is prolonged on each side to the insertion of the wings which are long and narrow, and once folded longitudinally when at rest; the fore pair have two or three subcostal cells; the hind shanks and tibiæ are smooth. The eggs, when first laid, are globular, soon becoming oval.

The larvæ of this family are soft, fleshy, with larger heads in proportion to the rest of the body, than in the *Apiariæ;* the antennal tubercle, or rudimentary antennæ, are more distinct, and the mandibles are larger. The surface of the body is smoother in Vespa and Polistes, but more tuberculated in the solitary genera, Odynerus and allies, while the end of the body is more acute.

As in the *Apiariæ* the higher genera are social, building papery nests, while the lower are solitary and build cells of mud or sand in protected places.

In *Vespa*, the Paper Wasp, the ligula is squarish, with the paraglossæ nearly as long as the tongue, the outer maxillary lobes rounded oval, half as long as the palpi, and the labial maxillæ are scarcely longer than the tongue. The abdomen is broad at base, acutely conical. The nests are either with or without a papery covering, supported by a short pedicel.

Such females as have hybernated, begin to make their cells in the early part of summer. Smith states that the solitary female wasp "begins by making three saucer-shaped receptacles, in each of which she deposits an egg; she then proceeds to form other similar-shaped receptacles, until the eggs first deposited are hatched and the young grubs require a share of her attention. From the circular bases she now begins to raise her hexagonal cells, not building them up at once, but from time to time raising them as the young grubs grow. (Proc. Ent. Soc., London, 1858, p. 35.)

Waterhouse states that the cells formed by the solitary female early in the season appear "to be built entirely of glistening, whitish, silk-like threads which I have little doubt are a secretion from the insect, all the threads being firmly attached together as if they had originally been of a glutinous nature." The cells formed later in the season by the workers, differ in consisting of masticated rotten wood. "Almost simultaneously with the commencement of the cells, it appears that the nest-covering is commenced. At first it has the appearance of a miniature umbrella, serving to shelter the rudimentary cells." Plate 5, Fig. 3, shows a group of cells surrounded by one layer of paper, and the beginning of another. As the nest grows larger the cells are arranged in galleries, supported by pedicels, and the number of layers in the outside covering greatly increases in number.

Fig. 83.

While our common and largest species, *Vespa maculata* Linn. (Fig. 83), and the yellow wasp, *V. arenaria* Fabr., build papery nests consisting of several galleries, with the mouth of the cells directed downwards, the East Indian species, *V. orientalis*,

builds its cells of clay, and, according to Waterhouse, "the work is exceedingly beautiful and true." Another species, according to Smith, makes its nest of sandy loam, the exterior being so hard that a saw used in opening one of its sides was blunted.

The larva of *Vespa arenaria* is long and cylindrical, not so much curved as in Polistes. Its position in its cell corresponds to its form, as the cell is longer and narrower than that of Polistes. Each segment of the body is posteriorly somewhat thickened, as is the lateral (pleural) ridge of the body. The tip of the abdomen is rather blunt, the last sternite being large and transverse. The pupa is provided with a single tubercle on the vertex, where there are two in the *Crabronidæ* and *Sphegidæ*.

By the time the nest of V. arenaria is large enough to contain ten full-grown larvæ, and has about fourteen cells in all, being about an inch in diameter, the occupants of the two or three central cells will have changed to pupæ, and one wasp will have been excluded.

In a nest of the same species two inches in diameter, there were a second brood of larvæ. The outer row of cells were occupied by pupæ, while the central ones, emptied of the first brood, were filled with a second brood of larvæ. Evidently as soon as an imago leaves its cell, the female deposits an egg therein, as very minute larvæ were found occupying cells next to those containing large full-grown larvæ.

In comparing a number of pupæ from a large nest, they will be found to be in all stages of perfection, from the larva which has ceased feeding, and is preparing to transform, to the imago, still veiled by its thin subimago pellicle. It is difficult to draw lines between these stages. Also when compared closely side by side, it is difficult, if not impossible to find any two pupæ just alike, the development proceeding very unequally. Thus the limbs may be more perfect than the antennæ, or certain parts may be less perfect in some than in others, while the limbs may be more highly colored like the imago.

Like the bees, Vespa suffers from numerous parasites, including Rhipiphorous paradoxus, which is a beetle allied to Stylops, and Lebia (Dromius) linearis. The larva of Volucella is said

to feed on the Vespa-larvæ, and Mr. Stone says that Anthomyia incana is also parasitic in Wasps' nests, while two species of Ichneumons, one of which is Anomalon vesparum, also infest the larvæ. No parasites have been as yet detected in this country.

The Hornet, *V. crabro* Linn., has, according to Mr. Angus, become domesticated about New York. This and the smaller wasps are sometimes injurious by eating into ripe fruit, but the injury is more than counterblanced by the number of flies and other insects they feed their young with.

Indeed, as Saussure states, the species of Vespa are more omnivorous in their tastes than any other wasps. They live by rapine and pillage, and have obtained a worse repute than other insects more injurious. In spring and early summer they feed on the sweets of flowers ; but later in the season attack strawberries, plums, grapes, and other fruits, and often enter houses and there help themselves to the dishes on the table. They will eat raw meat, and then aid the butcher by devouring the flies that lay their eggs on his meats. They will sometimes destroy Honey-bees, attacking them on their return from the fields laden with pollen ; they throw themselves upon their luckless victims, and tear the abdomen from the rest of the body, and suck their blood, devouring only the abdomen. They fall upon flies and butterflies, and, biting off their wings, feet, and head, devour the trunk. In attacking insects they use only their powerful jaws, and not the sting, differing in this respect from the fossorial wasps.

Saussure states that though wasps do not generally lay up food, yet at certain periods they do fill the cells with honey.

The females feed their young with food chewed up and reduced to a pulp. Saussure questions whether the larvæ of one sex are not fed on animal and the other on vegetable food, since Huber had shown "what a great influence the kind of food exerts on the sex of Bees." But it is now known that the sexes of some, and probably all insects are determined before the larvæ is hatched. I have seen the rudiments of the ovipositor in the half-grown larvæ of the Humble-bee, and it is most probable that those rudiments began to develop during embryonic life. It is far more probable that the sexual differences are determined at the time of conception.

Westwood states that the larvæ, which live head-downward from the reversed position of the comb, retain their position in the cell, while young, by a glutinous secretion, and afterwards "by the swollen front of the body which fills the open part of the cell." "The female cells are mostly placed apart from those of the males and neuters, those of the males being often mixed, but in a small number, in the neuter combs. The egg state lasts eight days, the larva state thirteen or fourteen, and that of the pupa about ten. After the imago has been produced, one of the old workers cleans out the cell, and fits it for the reception of a fresh inhabitant. The upper tier of cells, being first built, serves for the habitation of the workers; the females, being produced at the end of the summer, occupy the lowest tiers." When about to transform the larvæ spin a thin covering, thus closing over the cell.

In *Polistes* the paraglossæ are slender, and a little longer than the long, or as in one instance noticed by us in *P. Canadensis*, barrel-shaped ligula, which is split at the end; the palpi are stouter, while the whole body is much longer than in Vespa; the abdomen is subpedunculate, and the thorax is rather oblong than spherical, as in Vespa.

The larva differs from that of Vespa in its much larger head, and shorter, more ovoid form of the body, which is dilated in front so as to retain the insect in its cell, while the tip is more acute; the antennal tubercles are closer together; the clypeus is more regularly triangular and more distinct, while the labrum is much larger and excessively swollen, as are the mouth-parts generally. The mandibles are bidentate, where in Vespa they are tridentate. The pupa differs from that of Vespa, besides the usual generic characters, in having the tubercle on the head smaller.

The nests of Polistes (Plate 5, Fig. 4, nest of *P. annularis* Fabr., from Saussure) are not covered in by a papery wall as in Vespa, but may be found attached to bushes, with the mouth of the cells pointed downwards. While at Burksville Junction, Va., in the last week of April, I had an opportunity of watching three species beginning their cells on the same clump of bushes. They all worked in the same method, and the cells only differed slightly in size. The cells were formed mostly of

crude silk, and the threads could be seen crossing each other, the same structure being observed at the top and bottom of each cell.

In the three-celled nest of Polistes (Plate 5, Fig. 5, 5*a*) first noticed April 29th, there were but two eggs deposited, the third cell being without an egg, and a little smaller, and the rim not so high as in the other two. The outer edge did not seem to be perfectly circular, though stated by Waterhouse to be so in the incipient cells, for in some cases we detected two slight angles, thus making three sides, which, however, would be easily overlooked on casual observation; as there are only two sides within, the cell, from being at its earliest inception hemispherical, or "saucer-shaped," becomes five, and subsequently six-sided, and thus from being circular, it is converted by the wasps into a hexagonal cell. In some cells, perhaps a majority, both in this and the other species, the newly made rim of the small cells is thinner than the parts below, and slightly bent inwards; thus being quite the reverse of the thickened rim of the cells of the Hive Bee. It would seem that the wasp plasters on more silk, especially on the angles, building them out, and making them more prominent, in order to complete, when other cells are added, their hexagonal form. The three cells are of much the same size and height when the third egg is laid, as we observed in another nest, that of *Polistes Canadensis* (Linn.), built at the Defences of Washington, near Munson's Hill, June 9th.

Again, when one or two more cells have been added to the nest, and there are four or five in all (Plate 5, Fig. 6; 6*a*, top view, in which there are four cells), two of them are nearly twice as large as the others, while the fifth has been just begun, and is eggless. The form of the two which run up much higher than the others is the same as that of the smaller and shorter ones, *i.e.* they are on one side nearly semicircular, and on the other, partly hexagonal, and the angular sides show a tendency to be even more circular than when the others are built around them, for the little architect seems to bring out the angles more prominently when carrying up the walls of the other cells. Thus she builds, as if by design, one and the same cell both by the "circular" and "hexagonal" methods, afterwards adopt-

ing only the latter, and if she devotes her attentions specially to plastering the corners alone, with the design of making the cell six-sided, then we must allow, contrary to Mr. Waterhouse's views, that the wasp builds the hexagon by choice, and not as the mere result of her blindly "working in segments of circles;" for if our point be proved, and the most careful observation of the wasp while at work is needed to prove it, then it may be shown that the wasp is a free agent, and can abandon one method of working at a certain stage of her work, and adopt a different mode of operating.

The eggs are oval, pointed at the end, and glued to the inside of the cell. They are situated midway from the top and bottom of the incipient cell, and placed on the innermost sides, so that in a group of several cells the eggs are close together, only separated by the thin cellular walls. In a completed cell the egg is placed very near the bottom.

For several days a *Polistes Canadensis* was engaged in building its nest in my tent in camp near Washington. When first noticed on June 9th, there were three cells, two of which contained eggs; and it was not for two days, the 11th, that the third cell was completed, and a third egg deposited in it. The wasp paid especial attention to strengthening the pedicel, going over it repeatedly for an hour or two with its tongue, as if laying on more silken matter, and then proved the work by its swiftly vibrating antennæ. It would often fly out of the tent, and on its return anxiously examine each cell, thrusting its head deep down into each one. It gradually became accustomed to my presence, but eventually abandoned the nest, without adding more cells. The others, while at work on the bushes, absconded at my approach, and seemed very wary and distrustful, as if desirous of concealing their abodes. Mr. Smith has found *Trigonalys bipustulatus* to be a parasite on *Polistes lanio* Fabr. (*P. Canadensis* Linn.), from St. Salvador, S. A.

Saussure arranges the higher Vespidæ into two parallel series. Vespa is offset by Chartergus and Nectarina; lower down we find Tatua and Synœca, while Polistes is offset by Polybia. These five genera are tropical, and in their habits, the general appearance of their nests, and in the number of individuals represent Vespa and Polistes of the temperate zone. The

genus *Nectarina* is a short plump wasp, somewhat like Odynerus in shape; its distinguishing mark is the concealment of the postscutellum by the scutellum. *Nectarina mellifica* Say, of Mexico, builds a large nest externally like that of a wasp, but it is more irregular, and the papery covering consists of but one layer. The interior of the nest is very different, the galleries of cells, instead of being parallel, being arranged in concentric spheres.

Chartergus has the tip of the clypeus slighted excavated, and an oval sessile abdomen. *C. chartarius* Olivier makes an exceedingly thick tough nest, attached by a broad base to the bough of a tree, about twice as long as thick, and ending in a cone, pierced in the centre by the entrance which passes through the middle to the basal gallery; the other galleries are formed by a continuation of the sides of the nest, and arrayed in a conical plane.

In *Tatua*, the abdomen is pedicelled, but the petiole is not enlarged, and the abdomen itself is very regularly conical. *T. morio* Cuvier, from Cayenne, forms a nest like that of Chartergus; but the galleries form a flat floor, and each gallery has an entrance from the outside of the nest, where in the latter there is one common entrance. Plate 5, Fig. 9, shows how the bases of the cells are laid out on the edge of a gallery. In *Synœca* the peculiarly shaped abdomen is cordate and compressed. The curious nest of *S. cyanea* Fabr. is formed of a single layer of cells fixed against the trunk of a tree, and covered in with a dense covering made from the bark of dead trees. Some nests of Synœca are three feet long. In the very extensive genus *Polybia*, which resembles Polistes in its general shape, the abdomen is pedicelled, and the mandibles are four-toothed. The nests are somewhat like those of Chartergus, but much smaller. Several species occur in Mexico, and in Brazil the number of species is very great. In *Apoïca* the abdomen is very long, and the third segment is as long as the second. Plate 5, Fig. 11, represents the nest of *Apoïca pallida* Olivier, from Cayenne. It is unprotected, with a conical base, and with a single row of cells.

In *Icaria* we have an approach to Polistes in the slender series of cells composing the nest, forming two or three rows

only. Plate 5, Fig. 7, represents the nest of *I. guttatipennis* Saussure, from Senegal; 8, ground plan of a similar nest. These wasps are mostly distinguished from Polybia by the petiole ending in a globular mass. Plate 5, Fig. 10, represents the elegant nest of *Mischocyttarus labiatus* Fabr., from Cayenne and Brazil, which consists of a few cells supported by a long pedicel. The wasp itself much resembles Polistes, but the petiole is very much longer.

The remaining genera noticed here are solitary, building separate cells, and with only males and females. There are three subcostal cells in the fore wings, and the maxillæ and labium are much elongated.

In Eumenes the abdomen has a long pedicel, being sessile in Odynerus. While authors place Eumenes higher than Odynerus, we would consider the latter as a higher, more cephalized form, since the abdomen is less elongated, and the head is larger.

In *Odynerus* the ligula is long, deeply forked at the slender extremity, while the slender paraglossæ are shorter, ending in a two-toothed claw-like tip; the maxillæ are slender, and the palpi have an elongated basal joint; the clypeus is nearly circular, toothed on the front edge. The larva differs from those of the higher *Vesparicæ*, in its more elongated head, the square clypeus, the unusually deep fissure of the bilobate labrum, and in the larger tubercles of the body, as the larva is more active, turning and twisting in its cell, while feeding on its living food; and in this respect it is more closely allied to the young *Crabronidæ*. In the pupa of *O. albophaleratus*, the tip is more incurved than in the pupa of Vespa, so that the hind legs (tarsi) reach to the tip, and the abdomen is rounded ovate, while in Vespa it is oblong.

The cells (Plate 4, Figs. 13, 14) of *Odynerus albophaleratus* Sauss. have been detected like those of Osmia in a deserted gall of Diplolepis confluens, where several were found in a row, arranged around one side of the gall, side by side, with the holes pointing towards the centre of the gall. The cells are half an inch long, and one-half as wide, being formed of small pellets of mud, giving a corrugated, granulated appearance to the outside, while the inside is lined with silk.

We have received from Mr. Angus deserted cells of Ceratina in a syringa stem, in which we detected a pupa of an Odynerus, perhaps *O. leucomelas*; the cell was a little shorter than that of the Ceratina it had occupied. The cocoon of the Odynerus was of silk, and almost undistinguishable from the old cocoon of Ceratina. The wasp had dispensed with the necessity of making a mud cell. If future research shows that either this or any other species makes a mud cell or not at will, it shows the intelligence of these little "free-agents;" and that a blind adherence to fixed mechanical laws does not obtain in these insects.

The larvæ of Odynerus and Eumenes are carnivorous. I found several cells of *O. albophaleratus*, June 22d, in the deserted nest of a *Clisiocampa*, which were stored with micro-lepidopterous larvæ and pupæ, still alive, having been paralyzed by the sting of the wasp. The larvæ of the wasp was short and thick, being, when contracted, not more than twice as long as broad; the rings of the body are moderately convex, and the pleural region is faintly marked. Prof. A. E. Verrill has discovered the cells of an Odynerus at New Haven, forming a sandy mass (Plate 5, Fig. 12) attached to the stem of a plant.

In *Eumenes* the lingua is very long, being narrower and more deeply divided than in Odynerus; the second subcostal space of the wings is long and narrow, while in Odynerus it is triangular. The genus is easily recognized by the very long pedicel of the abdomen. *Eumenes fraterna* Say constructs a thin cell (Plate 5,* Fig. 15) of pellets of mud, and as large

* EXPLANATION OF PLATE 5. Fig. 1. Mouth of the tunnel of *Augochlora purus*; from Emerton. Fig. 2. Cells of *Osmia pacifica*; communicated by Mr. Sanborn. Fig. 3. Vertical section of nest of *Vespa* with a group of primitive cells surrounded by one layer of paper, and part of another; from Saussure. Fig. 4. Nest of *Polistes annularis*; from Saussure. Fig. 5. Three primitive cells of Polistes; 5*a*, top view of the same, one being eggless. The sides adjoining are angular. Figs. 6 and 6*a*, a cell farther advanced, consisting of four cells, each containing an egg, and with the edges of the cells built up higher and more decidedly six-sided; original. Fig. 7. Cells of *Icaria guttatipennis*, showing that each cell is built up independently in regular hexagons. Fig. 8. Ground plan of a similar nest. Fig. 9. Ground plan of cells of *Tatua morio*; from Smith. Fig. 10. Nest of *Mischocyttarus labiatus*; from Saussure. Fig. 11. Nest of *Apoïca pallida*; from Saussure. Fig. 12. Nest of *Odynerus*: original. Fig. 13. Nest of *Odynerus albophaleratus*: original. Fig. 14. Mud cell of *Pelopæus flavipes*; original. Fig. 15. A row of spherical cells of *Eumenes fraterna*, with the female; original, from Harris.

as a cherry. It is attached by a short stout pedicel to bushes, and the cavity is filled with the larvæ of small moths.

Raphiglossa odyneroides, from Epirus, described by S. S. Saunders, makes elongated cells in galleries in briars, storing them with the larvæ of what he supposed to be weevils. The dark brown dense tough cocoon of a Chrysis was also found in the cells.

In *Masaris*, which connects the *Vespariæ* with the succeeding family, the wings are not completely folded when at rest; there are but two subcostal cells; the maxillæ are rudimentary; and the antennæ are clavate and eight-jointed. *Masaris vespoides* Cresson, inhabits Colorado Territory.

CRABRONIDÆ Latreille. *Sand-wasps*, *Wood-wasps*. In the more typical genera the head is remarkably large, cuboidal, while the clypeus is very short, and covered for the most part with a dense silvery or golden pile. The antennæ are geniculate, the long second joint being received, when at rest, in a deep frontal vertical groove; the mandibles are large, and of even width throughout, and the mouth-parts are rather short, especially the lingua, which is often, however, well developed. There is only one subcostal cell, except in the *Philanthinæ*. The thorax is sub-spherical, and the abdomen is either short and stout, or more or less pedicellate. The forefeet are adapted for digging and tunnelling, the forelegs in the females being broad and flat, and in the males, which are supposed to do no work, they are sometimes, as in C.Thyreopus, armed with vexhillate expansions.

The larva is rather short and thick, a little flattened on the under side, but much rounded above; the segments are convex above, the thoracic segments differing from the abdominal segments in not being thickened posteriorly on each ring. They spin either a very slight cocoon, or a thin dense brown oval cylindrical case, generally reddish brown in color. The pupæ have much the same character as the imago, with prominent acute tubercles above the ocelli.

The members of this family afford, so far as we are acquainted with their habits, most interesting examples of the interdependence of structure and the habits of insects. Most

of the species are wood-wasps, making their cells in cylindrical holes in rotten wood, or enlarging nail-holes in posts, as is the case with Crabro singularis, according to the observations of Mr. C. A. Shurtleff, thus adapting them to the requirements of their young. Other genera (Rhopalum pedicellatum, Stigmus fraternus, and Crabro stirpicola) avail themselves of those plants whose stem has a pith which they can readily excavate and refit for their habitations. The females provision their nests with caterpillars, aphidæ, spiders, and other insects.

This family is most difficult to classify; it consists rather of groups of genera, some higher and some lower, though as a general rule those genera with pedunculate abdomens are the lowest in the series. In illustration, we regard Stigmus, with its elongated decephalized body, as inferior to Blepharipus, which again is subordinate to the more cephalized Crabro, where the body is shorter, the abdomen sessile, the anterior part of the body more developed headwards, while its nests are constructed more elaborately. The genus Psen, for the same reason, is lower than Cerceris, of which it seems a degraded form.

Some of the most useful characters in separating the genera of this family are to be found in the form of the clypeus, its sculpturing and relative amount of pubescence or hirsuties; in the form and sculpturing of the *propodeum* (Newman), or thoracico-abdominal ring of Newport; while the tip of the abdomen presents excellent generic and also specific characters, depending on its grooved or flattened shape.

The species of this family are mostly found in the north temperate zone, being very abundant in North America and in Europe. The Pemphredoninæ occur far north in abundance, while Cerceris occurs farthest towards the tropics.

The subfamily *Philanthinæ* includes the three genera, *Philanthus*, *Eucerceris*, and *Cerceris*. In Philanthus (Fig. 84, wing), the head is short, transversely suboval, the clypeus longer than broad, with the first joint of the abdomen nearly as broad when seen from above as the succeeding one. Our more common form southward is *Philanthus vertilabris* Say (Fig. 85). In Europe *P. apivorus* provisions its nest with honey-bees.

Cresson remarks that *Eucerceris* (Fig. 86, fore wing of male; *a*, female) differs from Cerceris in the venation, which differs greatly in the two sexes. *E. zonatus* Say occurs in the west.


Fig. 84.

The species of *Cerceris* (Fig. 87, wing) have transversely oblong heads, the front of the head is flattened and destitute of hairs, and the rings of the abdomen are contracted, the middle part being unusually convex and coarsely punctured, while the basal ring is nearly one-half narrower than the succeeding ones. *Cerceris deserta* Say is our most common form. In Europe some species are known to store their nests with bees, and the larvæ of *Curculionidæ* and *Buprestidæ*. Dufour unearthed in a single field thirty nests of *C. bupresticida* which were filled with ten species of Buprestis, comprising four hundred individuals, and none of any other genus. *Cerceris tuberculata* provisions its nest with Leucosomus ophthalmicus; and *C. tricincta* with Clythra.


Fig. 83.


Fig. 85.


Fig. 86 *a*.


Fig. 87.

In the subfamily *Crabroninæ*, there is a great disparity in the sexes, the form of the females being the most persistent. In the male the head is smaller, narrow behind, with shorter mandibles, and a narrower clypeus; the body is also much slenderer, especially the abdomen, and the legs are simple in Crabro, but in Thyreopus variously modified by expansions of the joints, especially the tibia. The species of *Crabro* (Fig. 88) are readily distinguished by the large cubical head, and the sharp mucronate abdominal tip of the female. The more typical form of this very extensive genus is *Crabro sex-maculatus* Say, so-called from the six yellow spots on the subpedunculate abdomen. According to Dr. T. W. Harris (MS. notes), this wasp was seen by Rev. Mr. Leonard, of Dublin, N. H., burrowing in decayed wood, June 10th.


Fig. 88.

Crabro singularis Smith, was discovered by Mr. C. A. Shurtleff boring in a post.

In *Thyreopus*, the body is slender, and the forelegs are curiously dilated in the males, often forming a broad expansion, and so dotted as to present a sieve-like appearance, while the head is much shorter, being more transverse. *T. latipes* Smith is known by the broad, long, acute, mucronate, shield-like expansion of the fore tibia, which is striped with black at the base.

The species of *Rhopalum* are usually blackish, without the gay colors prevalent in the genera before mentioned; the legs are simple, and the abdomen is long and slender, with a long peduncle. The body of the larva is short and thick, tapering rapidly towards each extremity; the segments are convex, those of the thorax especially being smooth, broad, and regularly convex, while the abdominal rings are provided with prominent tubercles. The tip of the body is quite extensible, and when protruded is subacute, terminating in a small knob-like body, formed by the last ring. The larvæ of this genus differ from those of the *Vesparicæ* and *Apiaricæ* known to us by having a few hairs scattered over the body.

In the pupa the antennæ, in their natural position, do not quite reach to the second pair of trochanters, and reach only to the tip of the maxillary palpi. The tip of the abdomen is very acute and elongated unusually far beyond the ovipositor. On the head, between the ocelli and antennæ, are two very prominent, acute tubercles, and the abdominal segments are dentate on the hind edge. Thus both the larva and pupa would seem, by their anatomy, to be unusually active in their loose, illy-constructed cells, which do not confine their food so closely as in the other wasps, as the insects on which they probably feed have a greater range in their rather roomy cells. April 18th we opened several stems grown in the open air, and found both larvæ and pupæ; the latter in different stages of development. The cells were placed in the closely packed dust made by the larva of an Ægeria, or directly bored in the pith of the plants. There were six such cells, each with its inhabitant, within a space an inch in length, some laying crosswise, others along the middle. The larvæ spin but a very

slight cocoon, not at all comparable with that of Crabro; the walls of the cell being simply lined with silken threads. Under other circumstances, *i. e.* where the cells are more exposed, it is not unlikely that a more elaborate cocoon may be spun.

Mr. James Angus has bred numerous specimens of *Rhopalum pedicellatum* Pack., from stems of the Rose, Corcorus, Japonica, and Spiræa, grown in hot-houses at West Farms, N. Y. The larva is a quarter of an inch long.

The following genera belong to the subfamily *Pemphredoninæ:*

The genus *Stigmus*, as its name indicates, may at once be known by the very large pterostigma, as well as the unusually small size of the species. The body of the larva is moderately long and slender, cylindrical, tapering slowly towards both extremities. The rings are short, very convex, subacutely so, and the larva is of a beautiful roseate color. *Stigmus fraternus* Say burrows in the stems of the Syringa, of which specimens have been received from Mr. Angus with the larvæ and pupæ.

In *Cemonus* the front narrows rapidly towards the insertion of the mandibles, and there is a short triangular enclosure on the propodeum, while the abdomen is shorter and thicker than in *Pemphredon*, a closely allied genus; the pedicel is also longer. The larvæ of *Cemonus inornatus* Harris live in irregular burrows in the elder, like those of Rhopalum from which they have been reared by Mr. Angus. They are known by the broad flattened head and body, serrate side and tergum of the body, and large, conspicuously bidentate mandibles, as well as by the peculiarly flattened abdominal tip.

In *Passalœcus* the labrum is very prominent, while the mandibles are very large, widening towards the tip, and in the common *P. mandibularis* Cresson they are white, and thus very conspicuous. This species burrows in company with the other wood-wasps mentioned above in the stems of the elder and syringa. The cells are lined with silk. The wasps appear early in June. Their nests are tenanted by Chalcids. The female stores her cells with Aphides, as we have found them abundantly in stems of plants received from Mr. Angus.

The genus *Psen* seems to be a degraded Cerceris, but the

abdomen is pedicelled, and differs from *Mimesa*, a still more slender-bodied genus, in having the tip of the abdomen more or less grooved, while in Mimesa it is flat and not grooved at all.

Psen leucopus Say has a dense silvery pile on the front of the head, with black antennæ, and the pedicel is rather short.

Nyssonidæ Leach. In this family the head is transversely longer and less cubical than in the preceding group; the vertex is higher and more convex, while the front is narrow, the clypeus long and narrow, the eyes long and narrow, and the antennæ are more clavate than in the *Crabronidæ*, and the propodeum is sometimes armed with acute spines, while the enclosed space is smoothly polished or striated. The wings are long and narrow, and the abdomen is sessile in the typical genera, where it is obconic, but clavate when pedicellate.

In *Trypoxylon* the body is long, with a pedicellate clavate abdomen. In Europe "Mr. Johnson has detected it frequenting the holes of a post pre-occupied by a species of Odynerus, and into which it conveyed a small round ball, or pellet, containing about fifty individuals of a species of Aphis; this the Odynerus, upon her return, invariably turned out, flying out with it, held by her legs, to the distance of about a foot from the aperture of her cell, where she hovered a moment, and then let it fall; and this was constantly the case till the Trypoxylon had sufficient time to mortar up the orifice of the hole, and the Odynerus was then entirely excluded; for although she would return to the spot repeatedly, she never endeavored to force the entrance, but flew off to seek another hole elsewhere."

T. politum Say has purplish wings, and no enclosure on the propodeum.

T. frigidum Smith lives in the stems of Syringa, from which it has been reared by Mr. Angus. The thin, delicate cocoon is long and slender, enlarging slightly towards the anterior end.

The genus *Mellinus* (belonging to the third subfamily, *Mellininæ*,) is known by its broad front, and slender antennæ, and its pedunculate abdomen, while in *Alyson*, a slender-bodied genus, it is sessile. *Mellinus bimaculatus* Say has a black head, with pale tipped antennæ, and two ovate yellow spots on the abdomen. *Alyson oppositus* is black, with two

yellow spots on the abdomen, which has the basal ring yellowish red in the female.

The fourth subfamily is the *Nyssoninæ*, so named from Nysson, a typical genus.

The genus *Gorytes* is truly a mimetic form, closely simulating the genus Odynerus, one of the *Vespariæ*. The front of the head is narrow, while the clypeus is larger than usual. The species are numerous, occurring late in the summer on the flowers of Spiræa. *Gorites flavicornis* Harris is polished russet brown, with narrow yellow rings on the abdomen, the propodeum is smooth and polished, and the basal ring of the abdomen is black. A species has been observed in Europe protruding her sting into the frothy secretion of Tettigoniæ living on grass, and carrying off the insect to provision its nest with.

Oxybelus is a short, stout, black genus, with whitish abdominal spots, and stout spines on the thorax, while the sessile abdomen is distinctly conical. "Its prey consists of Diptera, which it has a peculiar mode of carrying by the hind legs the while it either opens the aperture of its burrow or else forms a new one with its anterior pair. Its flight is low, and in skips; it is very active." (Westwood.)

Oxybelus emarginatus Say has two oval membranous appendages to the metathorax, and is a common black species found abundantly on the flowers of the Virginia Creeper.

In *Nysson* the body is a little longer, narrow compared with that of Oxybelus, while the terminal joint of the antennæ is thickened, flattened, and excavated beneath. *Nysson lateralis* Say is dull black, with six light spots on the abdomen.

The species of *Stizus* are of large size and easily recognized by their hirsute body, stout legs, triangular silvery clypeus, and the high transverse vertex of the head. The propodeum has a faintly marked triangular enclosure. The species are very rapacious, paralyzing grasshoppers and other large insects with their formidable sting, and carrying them off to provision their nests. Professor S. Tenney has sent us a specimen of the Dog-day Cicada (C. canicularis) which *Stizus speciosus* had thus stung. Mr. Atkinson has observed the same fact, and has found the deep burrows of this species, the hole being three-fourths of an inch in diameter. He has observed it feeding on sap running from a tree.

The species of *Larra* are smaller, and differ from those of Stizus in the long, narrow, very prominent labrum, the shorter clypeus, broader front and longer abdomen, the tip of which is without the broad subtriangular area which is present in Stizus and the other genera of this family. *Larra unicincta* Say is blackish, with a single reddish band on the second abdominal ring.

Bembecidæ Latreille. We have but two genera, *Bembex* and *Monedula*, which have large heads and flattened bodies, bearing a strong resemblance to Syrphus flies from their similar coloration. The labrum is very large and long, triangular, like a beak. The species are very active, flying rapidly about flowers with a loud hum. "The female Bembex burrows in sand to a considerable depth, burying various species of Diptera (Syrphidæ, Muscidæ, etc.), and depositing her eggs at the same time in company with them, upon which the larvæ, when hatched, subsist. When a sufficient store has been collected, the parent closes the mouth of the cell with earth." "An anonymous correspondent in the Entomological Magazine, states that *B. rostrata* constructs its nests in the soft light sea-sands in the Ionian Islands, and appears to catch its prey (consisting of such flies as frequent the sand; amongst others, a bottle-green fly) whilst on the wing. He describes the mode in which the female, with astonishing swiftness, scratches its hole with its forelegs like a dog. *Bembex tarsata*, according to Latreille, provisions its nests with *Bombylii*." (Westwood.) Dufour states that two Diptera, Panopea carnea and Toxophora fasciata, the latter allied to Systrophus, are parasites on Bembex. Mr. F. G. Sanborn has noticed the exceedingly swift flight of our common *Bembex fasciata* Fabr. on sandy beaches where it is found most abundantly.

Monedula differs from Bembex in its slenderer body, more clavate antennæ, and its shorter, very obtuse labrum. The body is smoother, and most generally more highly colored and more gaily spotted than in Bembex.

Monedula Carolina Fabr. and *M. 4–fasciata* Say are common southwards of New England.

Larridæ Leach. Mr. F. Smith defines this family as having "mandibles notched exteriorly near the base; the labrum con-

cealed, with a single spine at the apex of the intermediate tibiæ; the abdomen is ovoid-conical."

The genus *Astata* is a large hairy form, with long antennæ and palpi and an elongated prothorax. Its spiny legs show its near relationship to the *Sphegidæ*. *Astata unicolor* Say represents the genus in this country.

Tachytes is also of larger size than the following genus. It is covered with long dense golden short hairs, with a trapezoidal front. *Tachytes aurulentus* Fabr. is rare; it frequents the flowers of the Asclepias, as we have found pollen masses attached to the spines of its legs. We figure (89) a tarsus of a wasp belonging probably to this genus, received from Mr. V. T. Chambers, showing the pollen masses of Asclepias attached to the spines.

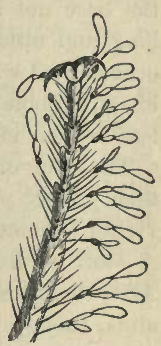


Fig. 89.

The genus *Larrada* "contains those species which have the marginal cell truncated at the apex and appendiculated, and three submarginal cells, the first as long as the two following; .... the metathorax [propodeum] truncated posteriorly, elongate, the sides being generally parallel; the mandibles are large and arcuate, with a tooth on their exterior towards the base; abdomen ovate-conical, acuminate at the apex." *Larrada argentata* Beauv. is covered with silvery pile. It is a slender form, with short, nearly unarmed legs.

A Brazilian species of *Larrada*, according to Mr. H. W. Bates, builds a nest composed apparently of the scrapings of the woolly texture of plants; it is attached to a leaf, having a close resemblance to a piece of German tinder, or a piece of sponge. The cocoons were dark brown, and of a brittle consistency. The reporter, Mr. F. Smith, adds: "I am not aware of any similar habit of building an external nest having been previously recorded; our British species of the closely allied genus Tachytes, are burrowers in the ground, particularly in sandy situations; their anterior tarsi are strongly ciliated, the claws bifid and admirably adapted for burrowing. On examining the insect which constructed the nest now exhibited, I find the legs differently armed; the anterior pair are not ciliated,

and the claws are simple and slender, clearly indicative of a peculiar habit differing from its congeners, and how admirably is this illustrated in the nest before us?"

SPHEGIDÆ Latreille. Smith defines this family as having "the posterior margin of the prothorax not prolonged backwards to the insertion of the wings, and anteriorly produced into a neck, with the abdomen petiolated." The very fossorial legs are long and spiny, the posterior pair being of unusual length. The mandibles are large, curved, narrow, and acute, the base not being toothed externally, and the antennæ are long and filiform. The species are often gaily colored, being ornamented with black and red, brown and red, or are entirely black, or blue. They love the sunshine, are very active, restless in their movements, and have a powerful sting.

The sting of these and other wasps which store up insects for their young, penetrates the nervous centres and paralyzes the victim without depriving it of life, so that it lives many days. A store of living food is thus laid up for the young wasp. After being stung the caterpillars will transform into chrysalids, though too weak to change to moths. Mr. Gueinzius, who resides in South Africa, observes that "large spiders and caterpillars became immediately motionless on being stung, and I cannot help thinking that the poisonous acid of Hymenoptera has an antiseptic and preserving property; for caterpillars and locusts retain their colors weeks after being stung, and this, too, in a moist situation under a burning sun."

These insects either make their nests in the sand, or, like the succeeding family, are "mud-daubers," building their cells of mud and plastering them on walls, etc.

The tropical genus *Ampulex* is more closely allied to the preceding family than the other genera. The species are brassy green. Dr. G. A. Perkins has described in the American Naturalist, vol. 1, p. 293, the habits of a wasp, probably the *Ampulex Sibirica* Fabr., which inhabits Sierra Leone, and oviposits in the body of the cockroach. The dead bodies of the cockroaches are often found with the empty cocoon of the wasp occupying the cavity of the abdomen.

A species of this genus, abundant at Zanzibar at certain sea-

sons, was frequently observed by Mr. C. Cooke to attack the cockroach. The cockroach, as if cowed at its presence, immediately yields without a struggle. The Ampulex stings and paralyses its victim, and then flies away with it.

Chlorion is closely allied, containing blue and metallic green species, often with golden yellow wings. *Chlorion cyaneum* Dahlb., a blue species, is found in the Southern States.

The genus *Priononyx* "differs from the genus Sphex in having the claws quadridentate beneath at their base; the neuration of the wings and the form of the abdomen are the same as in *Harpactopus*," which is found only in the tropics and Australia. *Priononyx Thomæ* is found from South Carolina to Brazil, including the West Indies.

The genus *Sphex* is quite an extensive one. The head is as wide as the thorax; the antennæ are filiform, mandibles large and acute, bidentate within, the teeth notched at their base, forming a rudimentary tooth, the apical tooth being acute. The thorax is elongate-ovate, truncated behind, with a transverse collar (prothorax). The fore wings have one marginal and three submarginal cells; the marginal cell elongate, rounded at its apex; the first submarginal cell as long as the two following. The abdomen is pedunculated, conically ovate, and the anterior tarsi are ciliated in the females.

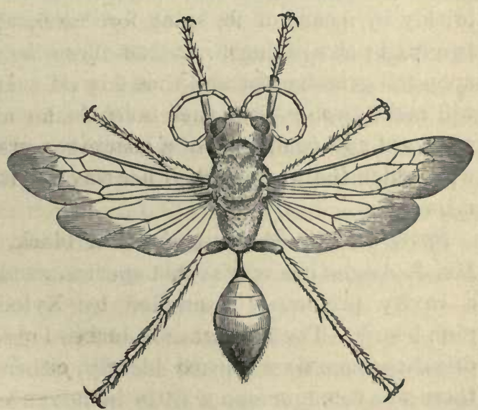


Fig. 90.

Sphex ichneumonea Linn. (Figure 90) is a large rust-red species, with a dense golden pubescence. It is common from Massachusetts southwards. In the last week of July, and during August and early in September, we noticed nearly a dozen of these wasps busily engaged in digging their holes in a gravelly walk. In previous seasons they were more numerous, burrowing into grassy

banks near the walk. The holes were four to six inches deep. In beginning its hole the wasp dragged away with its teeth a stone one half as large as itself to a distance of eight inches from the hole, while it pushed away others with its head. In beginning its burrow it used its large and powerful jaws almost entirely, digging to the depth of an inch in five minutes, completing its hole in about half an hour. After having inserted its head into the hole, where it loosened the earth with its jaws and threw it out of the hole with its jaws and fore legs, it would retreat backwards and push the dirt still farther back from the mouth of the cell with its hind legs. In cases where the farther progress of the work was stopped by a stone too large for the wasp to remove or dig around, it would abandon it and begin a new hole. Just as soon as it reached the required depth the wasp flew a few feet to the adjoining bank and falling upon an Orchelimum vulgare or O. gracile, stung and paralyzed it instantly, bore it to its nest, and was out of sight for a moment, and while in the bottom of its hole must have deposited its egg in its victim. Reappearing it began to draw the sand back into the hole, scratching it in quite briskly by means of its spiny fore tarsi, while standing on its two hind pairs of legs. It thus threw in half an inch of dirt upon the grasshopper and then flew off. In this way one Sphex will make two or three such holes in an afternoon. The walk was hard and composed of a coarse sea-gravel, and the rapidity with which the wasp worked her way in with tooth and nail was marvellous.

Sphex tibialis St. Fargeau is a black, stout, thick insect. Mr. J. Angus has reared this species, sending me the larvæ in a cavity previously tunnelled by Xylocopa Virginica in a pine board. The hole was six inches long, and the oval cylindrical cocoons were packed loosely, either side by side, where there was room, or one a little in advance of the other. The interstices between them were filled with bits of rope, which had perhaps been bitten up into pieces by the wasp itself; while the end of the cell was filled for a distance of two inches with a coarse sedge arranged in layers, as if rammed in like gun-wadding. The cocoons are eighty to ninety hundredths of an inch long, oval lanceolate, somewhat like those of Pompilus. They

consist of two layers, the outer very thin, the inner tough, parchment-like. The larvæ hybernate and turn to pupæ in the spring, appearing in the summer and also in the autumn.

The larva is cylindrical, with the pleural ridge prominent, and with no traces of feet; the head, which is small and not prominent, and rather narrow compared with that of Pelopæus, is bent inwards on the breast so that the mouth reaches to the sternum of the fourth abdominal ring. The posterior half of each ring is much thickened, giving a crenulated outline to the tergum. The abdominal tip is obtuse.

Sphex Lanierii Guerin, according to Smith (Proceedings of the Entomological Society of London, Feb. 7, 1859), constructs its nest of a cottony substance, filling a tunnel formed by a large curved leaf. The species of the genus are supposed to burrow in the ground, and the two cases above cited show an interesting divergence from this habit. Mr. Smith adds, that in "the Sphex which constructs the nest in the rolled leaf, the anterior tarsi are found to be very slightly ciliated, and the tibiæ almost destitute of spines, thus affording another instance proving that difference of structure is indicative of difference of habit."

The genus *Pelopœus* is of a slighter form than in Sphex, the body being longer and slenderer; the clypeus is as broad as long, triangular above, in front convex, or produced and ending in two teeth. The outer costal cell is lanceolate oval, the second subcostal cell subtrapezoidal, being widest above; it is also somewhat longer than broad. The first median cell is very long and narrow, much more so than usual. The pedicel of the abdomen is long, the first joint in the male being often as long as the remainder of the abdomen.

The larva of *P. cœruleus* Linn. is much like that of Sphex, having a cylindrical body with the rings thickened posteriorly. It differs from that of Pompilus in its longer and narrower head, the short broadly trapezoidal clypeus, and the distinctly marked exserted labrum. The mandibles are long and tridentate.

The pupa (of P. flavipes) differs from that of the *Vesspariæ* in having the head more raised from the breast; the palpi are not partially concealed, as they may be easily seen for their whole length. The long curved mandibles cover the base of the

maxillæ and lingua, and the antennæ reach to the posterior coxæ. The maxillæ are slender, not reaching to the tip of the labium.

The female usually provisions her cells (Plate 5, Fig. 14) with spiders. The cells are constructed of layers of mud of unequal length, and formed of little pellets placed in two rows, and diverging from the middle. They are a little over an inch long, and from a half to three-quarters of an inch wide, and are somewhat three-sided, the inner side next the object, either stone-walls or rafters, to which it is attached, being flat. As the earthen cells sufficiently protect the delicate larvæ within, the cocoons are very thin, and brown in color.

The cells of *Pelopœus flavipes* from Brownville, Texas, collected by an United States officer and presented to the Boston Society of Natural History, contained both spiders and numerous pupæ of a fly, *Sarcophaga nudipennis* Loew (MS) which is somewhat allied to Tachina. These last hatched out in midsummer a few days before the specimens of Pelopæus. It is most probable that they were parasitic on the latter. These specimens of P. flavipes were more highly ornamented with yellow than in those found northwards in the Atlantic States, the metathorax being crossed by a broad yellow band.

The genus *Ammophila* is a long slender form, with a petiolate abdomen, the tip of which is often red. The petiole of the abdomen is two-jointed, and very long and slender, being longer than the fusiform part. In the males the petiole is in some species much shorter. The wings are small, with the apex more obtuse than usual; the second subcostal cell is pentagonal, and the third is broadly triangular.

Westwood states that "the species inhabit sandy districts, in which *A. sabulosa* forms its burrow, using its jaws in burrowing; and when they are loaded, it ascends backwards to the mouth, turns quickly around, flies to about a foot's distance, gives a sudden turn, throwing the sand in a complete shower to about six inches' distance, and again alights at the mouth of its burrow."

"Latreille states that this species provisions its cells with caterpillars, but Mr. Shuckard states that he has observed the female dragging a very large inflated spider up the nearly perpendicular side of a sand-bank, at least twenty feet high, and

that whilst burrowing it makes a loud whirring buzz; and, in the Transactions of the Entomological Society of London, he states that he has detected both *A. sabulosa* and *A. hirsuta* dragging along large spiders. Mr. Curtis observed it bury the caterpillars of a Noctua and Geometra. St. Fargeau, however, states that *A. sabulosa* collects caterpillars of large size, especially those of Noctuæ, with a surprising perseverance, whereas *A. arenaria*, forming a distinct section in the genus, collects spiders." (Westwood.)

Ammophila cementaria Smith, and *A. urnaria* Klug, are the more common species in this country; they are red and white, while *A. luctuosa* Smith is a black, shorter, stouter, more hirsute species. They may all be seen flying about hot sandy places, and alighting near wells and standing water to drink.

POMPILIDÆ Leach. In this family the body is oblong, the sides often compressed, and the head shorter, when seen from above, being more transversely ovate than in the preceding family. The antennæ are long, not geniculate, and in the males are stouter and with shorter joints than in the females. The eyes are narrow oval, and the maxillary palpi are six, and the labial palpi four-jointed. The prothorax is extended on the sides back to the base of the wings,

Fig. 91.

which latter are large and broad, the fore pair having three subcostal cells. The legs are very long and slender, with thick slender spines. The *Pompilidæ*, of which about seven hundred species are known, have a wide geographical range, from the temperate zone to the tropics. Like the *Sphegidæ*, they oviposit in the body of other insects, storing their nests, usually built in the sand, with spiders and caterpillars.

The head of *Pompilus* (Fig. 91) is a little longer, seen from

above, than in the other genera; the front of the head is about a third longer than broad. The antennæ are long and filiform and sometimes crenulate, as in Figure 91 *a*, in the males; the mandibles are stout, broad, sabre-shaped, being much curved, with low flattened teeth, and the maxillary palpi are longer than the labial palpi. The wings are rather broad, with the three subcostal cells lying in a straight row. The abdomen is slightly compressed, and equals in length the remainder of the body. The sting is very large and formidable, and excessively painful, benumbing the parts it enters. They are exceedingly active, running and flying over sandy places like winged spiders.


Fig. 91 *a*.

There are about five hundred species of this genus described. They are usually shining black or deep bluish black, with smoky or reddish wings, and sometimes a reddish abdominal band. This genus is interesting, as affording in its form a mean between the globular thorax and short body of the *Apiariæ* and the elongated body of the *Ichneumonidæ*.

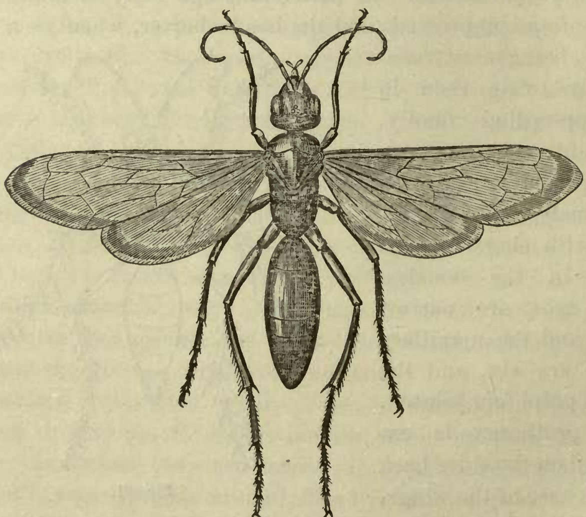


Fig. 92.

The *Pompilus formosus* Say (Fig. 92), called in Texas the Tarantula-killer, attacks that immense spider the *Mygale Hentzii*, and, according to Dr. G. Lincecum (American Naturalist, May,

1867), paralyzes it with its formidable sting, and inserting an egg in its body, places it in its nest, dug to the depth of five inches. There is but a single brood, produced in June, which is killed off by the frosts of November. This species feeds in summer "upon the honey and pollen of the flowers of the Elder, and of *Vitis ampelopsis*, the Virginia Creeper; but its favorite nourishment is taken from the blossoms of *Asclepias quadrifolium*." (Lincecum.) *P. cylindricus* Cresson (Fig. 93, wing) is one of our smallest species, being from three to five lines long. It occurs in the South and West. *P. arctus* Cresson (Fig. 94, wing) inhabits Colorado Territory. *P. Mariæ* Cresson (Fig. 95, ♀ enlarged) is a beautiful and rare species found in Pennsylvania. The genus *Priocnemis* is characterized by the two hind pair of tibiæ being serrated (♀, Fig. 96, *a*, wing; *b*, posterior leg; *c*, anterior leg), and by the want of spines on the anterior legs. *P. unifasciatus* Say is a wide-spread species and readily recognized by the deep black color of the body, the yellow antennæ and the large yellow spot at the tip of each anterior wing.

Fig. 93.

Fig. 94.

Fig. 95.

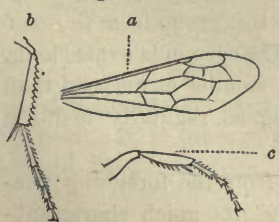


Fig. 96.

The genus *Agenia* (Fig. 97, *a*, wing; *b*, posterior leg) differs in having smooth legs. *A. brevis* Cresson (Fig. 98, wing) is a little species found in Georgia. *A. congruus* Cresson (Fig. 99, wing) was captured in West Virginia; and *A. acceptus* Cresson (Fig. 100, wing) in Georgia. The genus *Notocyphus* (Fig. 101, ♀, wing) is found in Brazil and Mexico. *Planiceps* (Fig. 102,

wing) contains a few species, of which *P. niger* Cresson, an entirely black species, is found in Connecticut. *Aporus* (Fig. 103, wing) contains a single American species, *A. fasciatus* Smith, taken in North Carolina.

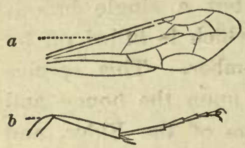


Fig. 97.

From Mr. F. G. Sanborn we have received the larva and cocoon of *Pompilus funereus* St. Farg., a small black species, which builds its nest in fields. The larva is short and broad, with the lateral region rather prominent, and the tip of the abdomen rather acute. It differs from Pelopæus in its stouter, rather flattened body, and thickened segments, though as our specimen is preserved in alcohol these characters may have become exaggerated. It more nearly resembles Pelopæus in its transverse clypeus, thin bilobate labrum, and the stout mandibles, which are, however, much stouter than in Pelopæus, while the whole head is shorter, broader, and rounder. It is probable that this peculiar form of the head (which as in Sphex is bent beneath the breast), together with the broad transverse clypeus, and broad, short, bilobate, thin, transparent labrum, and especially the unidentate short broad mandibles are family characters, separating the larvæ of this group from those of the *Sphegidæ*. The cocoon is ovate, long, and slender, much smaller at one end than the other, not being so regularly fusiform as in Sphex.

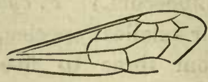


Fig. 99.

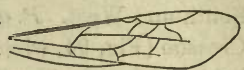


Fig. 101.


Fig. 102.


Fig. 103.


Fig. 98.


Fig. 100.

Ceropales differs from the foregoing genera in its broad head, its much shorter abdomen; and also in the eyes being a little excavated, in the depressed labium, the narrow front, which dilates above and below the middle, and in the greatly elongated hind legs, generally banded with red or whitish. *Ceropales bipunctata* Say is generally distributed throughout the United States. It

is easily recognized by the black body and legs, and red posterior femora, and is six lines long. *C. Robinsonii* Cresson (Fig. 104, ♂) is an elegant species found in West Virginia. An allied genus is *Mygnimia* (Fig. 105, wing) containing *M. Mexicana* Cresson and *M. ustulata* Dahlb., two Mexican species.

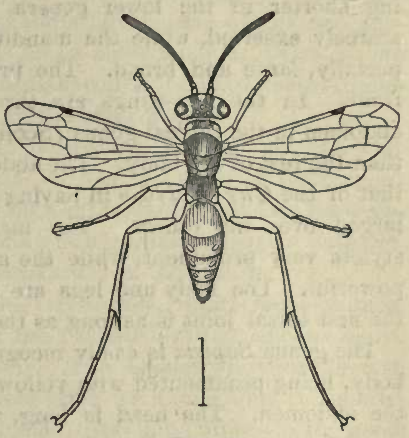


Fig. 104.

In the genus *Pepsis* (Fig. 106, wing) the maxillary and labial palpi are of equal length. The species are large, some of them being among the largest of Hymenoptera, and are generally indigo-blue in color. *Pepsis heros* Dahlbom is found in Cuba; it is two inches long. *P. cyanea* Linn., which is blackish-blue, with blue abdomen and wings, the latter reddish at the apex, has been described by Beauvois from the United States, while *P. elegans* St. Farg. also occurs in the Southern States.

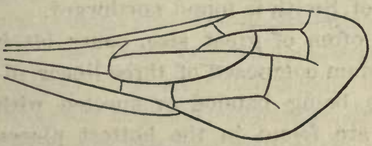


Fig. 105.

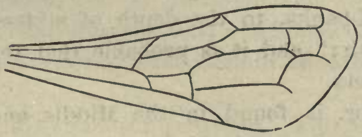


Fig. 106.

P. formosa Say affords another example of a species common to both sides of the Rocky Mountains, as it has been found both in Texas and California. It is black, with bluish or greenish reflections, with bright fiery red wings, and is thirteen to eighteen lines long.

Scoliadæ Leach. This family forms a group very easily distinguished from the *Bembecidæ* or *Chrysididæ*, as well as the *Pompilidæ*, by the broad front, the small indented eyes, and the great sexual differences in the antennæ, those of the male being long and slowly thickened towards the tip, while in

the female they are short, thick, and elbowed on the second joint. The clypeus is large, irregularly quadrilateral, becoming shorter in the lower genera, and the labrum is small, scarcely exserted, while the mandibles are, in the female especially, large and broad. The prothorax is very square in front. In the fore-wings are three subcostal spaces. The abdomen in the typical genus (Scolia) is broad and flat, longer than the rest of the body. The abdomen of Mutilla approaches that of the *Chrysididæ* in having the second ring much enlarged over the others. The males usually have the anal stylets very prominent, while the sting of the female is very powerful. The body and legs are generally very hirsute, and the first tarsal joint is as long as the tibiæ.

The genus *Sapyga* is easily recognized by its smooth slender body, being ornamented with yellow, with transverse bands on the abdomen. The head is long, very convex in front, and the antennæ are clavate; the prothorax is very broad, giving an oblong appearance to the thorax. The legs are slender and smooth. It is said to be parasitic, laying its eggs in the cells of Osmia. *Sapyga Martinii* of Smith is found northward.

The species of *Scolia* are often of great size, being black and very hirsute, with the labium composed of three linear divisions; the abdomen alone being banded or spotted with yellow on the sides. They are found in the hottest places about strongly scented flowers. In Europe, *Scolia bicincta* "makes its burrows in sand-banks, to the depth of sixteen inches, with a very wide mouth;" and it is probable that the nest is stored with grasshoppers.

Scolia quadrimaculata Fabr. is found in the Middle and Southern States. The larva of *Scolia flavifrons* was found by Passerini to live in the body of the lamellicorn beetle, Oryctes nasicornis. In Madagascar, *Scolia oryctophaga* lives on Oryctes simia, according to Coquerel.

Professor Sumichrast states that at Tehuacan (Department of Puebla) the *Scolia Azteca* Sauss. is very common; and is particularly abundant in the leather tanneries, which leads him to think that the females of this species also deposit their eggs under the epidermis of the larva which abounds in the tan.

Tiphia is black throughout and rather hirsute. The antennæ

are shorter than in Scolia or Myzine; the clypeus is also shorter, while the prothorax is longer. In the fore-wings the outer costal cell is short, broad, angulated, oval; and of the two subcostal cells, the outer one is broad and triangular, twice as long as broad, while the first median cell is regularly short rhomboidal, much more so than in the other genera.

The females, according to Westwood, "make perpendicular burrows in sandy situations, for the reception of their eggs; but the precise food stored up for the larvæ has not been observed." *Tiphia inornata* Say is a common species with us, and flies low over sandy places early in the season.

The short oval head, the large eyes, short meso-scutum, large meso-scutellum, and the flattened, rather smooth body, characterize the genus *Myzine*. The females are very different from the males, the two sexes being for a long time considered as separate genera. The female, especially, differs in the great length of the square prothorax, which is very broad and convex in front. In the male the eyes are lunate, while in the female they are small, entire, and remote. In its general form the females much resemble Scolia, while the males are long and narrow, with broad yellow bands, especially on the abdomen, and a large exserted sting-like organ. *Myzine sexcincta* Fabr. is seen from New England southwards, flying low over hot sandy places. The genus *Elis* is closely allied. Sumichrast (American Naturalist, vol. 2), surmises that *Elis costalis* St. Farg. lives on certain Scarabæides, which undergo their metamorphosis in the formicary of Œcodoma in Mexico.

MUTILLARIÆ Latreille. This interesting family is characterized by the females alone being wingless, though Morawitz says that wingless males occur in two species; and by the absence, generally, of the three ocelli. In Mutilla and Myrmosa the thorax is still high, compressed, and oblong cuboidal, and except in the closely united tergal pieces the females do not greatly recede from the type of the winged males. The species are very equal in size, are black, or black and red, and either smooth or hirsute.

The antennæ are inserted low down on the front, the clypeus being very short and broadly ovate (especially in Myrmosa),

or it is indented, as in Mutilla. The tongue is shorter than usual. The sides of the thorax contract in width, both before and behind. The meso-scutum is squarer than usual, while the meso-scutellum is much narrower and longer, and the propodeum is squarely truncated behind, thus presenting a full convex surface. The abdomen is not much longer than the rest of the body, being shorter than usual. In all these characters this family shows its affinities to the Ants. The wings are very dissimilar in the different genera. In Myrmosa the neuration closely approaches that of Sapyga, while in the larger, more acute primaries of Mutilla, and especially in the short outer costal cell, and short open pterostigma, the latter genus differs from the others.

The male of *Scleroderma* closely mimics the *Proctotrypidæ*, the veins of the wings being absent, while the form of the head and abdomen also reminds us of some genera in that family. The wingless female is very different, having more of the form of Mutilla, with a large oblong head and long acutely conical abdomen. The species are minute and rarely met with. *S. contracta* Westwood is found in "Carolina."

In the female *Methoca* the eyes are very long, and the segments of the abdomen are widely separated, much as in the ants. *Methoca Canadensis* Smith is shining black, and slightly villose.

Fig. 107.

The species of *Myrmosa* may be known by the very short clypeus, the broad vertex, and the rings of the abdomen of the male being unusually contracted. The abdomen of the female is cylindrical, about twice as long as broad, and thickest on the second ring. The rings are densely hirsute on the hinder edge. *Myrmosa unicolor* Say (Figs. 107, male; 108, female) is widely distributed. We have taken this species in Maine, while sexually united, early in June. The wingless female is like an ant, and is pale reddish on the thorax and basal ring of the abdomen, and the antennæ and feet are concolorous, while the head and remaining abdominal rings are much darker. It is .20 inch long. The male is .28 inch long and entirely black.

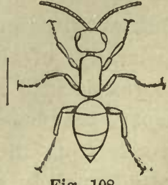


Fig. 108.

The genus *Mutilla* is a very extensive one, and enjoys a wide geographical range. It is throughout stouter than *Myrmosa*, the head is more cubical, and the thorax and abdomen is shorter, the tip of the latter being somewhat truncated.

The wingless female closely resembles, both in its form and motions, a worker ant. The body is coarsely granulated and either naked or densely hirsute, and of a scarlet, black, or pale red, or brown-black color. The females are found running in hot sandy places, and hide themselves quickly when disturbed, while the males frequent flowers. *Mutilla occidentalis* is a large species. It is of a beautiful scarlet color and is armed with a very powerful sting. According to Professor A. E. Verrill this species was found by him, at New Haven, to construct deep holes in a hard beaten path, storing its nest with insects. This species is also said by Kirby to be very active, "taking flies by surprise." (Westwood.) Mr. Verrill noticed that this insect makes a slight creaking noise. The larvæ of *M. Europæa* are said to live parasitically in Humble-bees' nests. *Mutilla ferrugata* Fabr. (Fig. 109) is found frequently in New England.

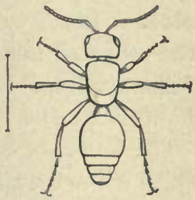


Fig. 109.

FORMICARIÆ Latreille. The family of ants would seem naturally to belong with the truly fossorial Hymenoptera, both from their habits and structure.

Both males and females are winged, but the males are much smaller than the females, while the wingless workers are smaller than the males. In these wingless forms the segments of the thorax become more or less separated, making the body much longer and slenderer, and less compact than in the winged normal sexual forms, the prothorax being more developed than in the males and females. The workers often consist of two forms: one with a large cubical head, or worker major, sometimes called a soldier, and the usual small-headed form, or worker minor.

The head is generally triangular. The eyes are large in the males, smaller in the workers, and in those of some genera (Ponera, Typhlopone, etc.) they are absent; while in the

workers the ocelli are often wanting, though present in the winged individuals of both sexes. The antennæ are long, slender and elbowed. The mandibles are stout, and toothed, though in those species that do not themselves labor, but enslave the workers of other species, they are unarmed and slender. The maxillary palpi are from one to six-jointed, and the labial palpi two to four-jointed. The fore-wings usually have but a single complete subcostal (cubital) cell. The sting is often present, showing that in this respect as well as their fossorial habits the ants are truly aculeate Hymenoptera. The larva is short, cylindrical, with the end of the body obtuse. The rings of the body are moderately convex. The head is rather small and bent upon the breast. The larvæ are fed by the workers with food elaborated in their stomachs.

The larvæ of the stingless genera usually spin a delicate silken cocoon, while those of the aculeate genera do not. Both Latreille and Westwood, however, state that sometimes, as in *Formica fusca*, of Europe, the pupæ are naked, and at other times enclosed in a cocoon.

The colonies of the different species vary greatly in size. In the nests of *Formica sanguinea* the number of individuals is very great. The history of a formicarium, or ant's nest is as follows: The workers only (but sometimes the winged ants) hibernate, and are found early in spring, taking care of the eggs and larvæ produced by the autumnal brood of females. In the course of the summer the adult forms are developed, swarming on a hot sultry day. The little yellow ants, abundant in paths and about houses in New England, generally swarm on the afternoon of some hot day in the first week of September, when the air is filled towards sunset with myriads of them. The females, after their marriage flight in the air, may then be seen entering the ground to lay their eggs for new colonies, or, as Westwood states, they are often seized by the workers and retained in the old colonies. Having no more use for their wings they pluck them off, and may be seen running about wingless. According to Gould, an early English observer, the eggs destined to hatch the future females, males and workers, are deposited at three different periods.

The nests of some species of Formica are six feet in diameter

and contain many thousand individuals. Ants also build nests of clay or mud, and inhabit hollow trees. They enjoy feeding upon the sweets of flowers and the honey of the Plant-lice, which they domesticate in their nests. Several species of beetles, including some of the *Staphylinidæ*, take up their abode in ants' nests. Ants are useful as scavengers, feeding on decaying animal matter. A good method of obtaining the skeletons of the smaller animals, is to place them on a densely populated ant-hill. The habits of the ants, their economy and slave-making habits, are described in the works of Huber, Latreille, and Kirby and Spence.

Upwards of a thousand species of ants have already been described; those of this country have still to be monographed.

The first group of this extensive family consists of Dorylus and its allies, and Formica and the neighboring genera, all of which are distinguished by having only the first abdominal segment contracted, while in the second group (*Myrmicariæ*), the two basal rings are contracted into knot-like segments.

The genus *Dorylus* was, by Latreille, Klug, and others, included in the *Mutillariæ*. The head is very short, the ocelli are large and globular. The thorax and abdomen are elongated, the last is cylindrical, with a small, round, basal joint. The legs are short, with broad compressed femora and feather-like tarsi. In the wings the outer subcostal cells are wanting. The females are not yet known. Mr. F. Smith says that Dorylus was found by Hon. W. Elliot to live in the manner of ants, under the stone foundation of a house in India. The society was very numerous. The difference in size of the male and worker is very remarkable. The males are of large size and are found in tropical Asia and Africa.

Typhlopone is an allied genus. *T. pallipes* Haldeman is found in Pennsylvania.

To the genus *Anomma* belong the Driver-ants of Western Africa. They march in vast armies, driving everything before them, so formidable are they from their numbers and bite, though they are of small size. They cross streams, bridging them by their interlocked bodies. Only the workers are known. Two species only, *A. Burmeisteri* Shuckard, and *A. arcens* Westwood, are described from near Cape Palmas, West Africa.

The genus *Ponera* is found distributed throughout the tropics. The females and workers are armed with spines; the abdomen is elongated, the segments more or less diminished in size, the first comparatively large and often cubical. The legs are slender. *P. ferruginea* Smith is a Mexican species.

The allied genus *Odontomachus* springs like some leaping spiders. It uses for this purpose its unusually long mandibles, which are bent at right angles. *O. clarus* Roger lives in Texas.

Formica includes the typical species of ants. Over two hundred species of this genus have been already described. The body is unarmed. The abdomen is short, oval or spherical, the scale-like first segment being lenticular in form, with a sharp upper edge. The subcostal cell of the fore-wings end in a point. *Formica sanguinea* Latr. is one of our most abundant species, making hillocks of sand or clay, according to the nature of the ground. From the formicary walks, and underground galleries, radiate in all directions. This species has been observed making forays upon each others colonies. We have found a variety of this species in Labrador, where it is common. It does not throw up hillocks, but tunnels the earth.

This species has been observed in Europe by P. Huber, to go on slave expeditions. They attack a "negro-colony" belonging to a smaller black species, pillaging the nest, and carrying off merely the larvæ and pupæ. The victors educate them in their own nests, and on arriving at maturity the negroes take the entire care of the colony. *Polyergus rufescens* is also a slave-making ant, and "Latreille very justly observes that it is physically impossible for the rufescent ants (*Polyergus rufescens*), on account of the form of their jaws, and the accessory parts of their mouth, either to prepare habitations for their family, to procure food, or to feed them." *Formica sanguinea* sallies forth in immensely long columns to attack the negro ant. Huber states that only five or six of these forays are made within a period of a month, at other seasons they remain at peace. Huber found that the slave-making *Polyergus rufescens* when left to themselves perish from pure laziness. They are waited upon and fed by their slaves, and when they are taken away, their masters perish miserably. Sometimes they are known to labor, and were once observed to carry their slaves to a spot chosen

for a nest. The *F. sanguinea* is not so helpless, "they assist their negroes in the construction of their nests, they collect their sweet fluid from the Aphides; and one of their most usual occupations is to lie in wait for a small species of ant on which they feed; and when their nest is menaced by an enemy they show their value for these faithful servants, by carrying them down into the lowest apartments, as to a place of the greatest security." (Kirby.) Pupæ of both of the slave-making species were placed in the same formicary by Huber, where they were reared by the "negroes," and on arriving at maturity "lived together under the same roof in the most perfect amity," as we quote from Kirby. Darwin states that in England, *F. sanguinea* does not enslave other species.

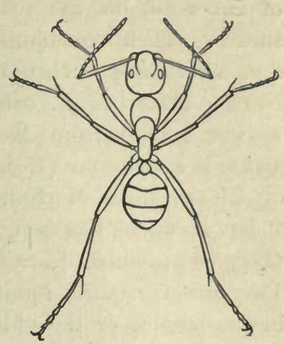


Fig. 110.

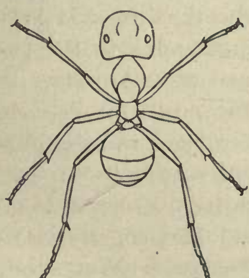


Fig. 111.

In this country Mr. J. A. Allen has described in the Proceedings of the Essex Institute, vol. 5, 1866, a foray of a colony of *F. sanguinea* upon a colony of a black species of Formica, for the purpose of making slaves of them.

Formica Pensylvanica, our largest species, is found in oaks and decaying trees, while *F. herculanea* Latr. burrows in the earth, its hole opening beneath stones and sticks.

Gould, who wrote in 1747, states that there are two sizes of workers of the common European *Formica rufa*, and *flava;* one set of individuals exceeding the other by about one-third. Kirby states that in his specimens "the large workers of *Formica rufa* are nearly three times, and of *F. flava*, twice the size of the small ones." Mr. E. Norton describes *F. fulvacea* (Fig. 110, worker minor), and also *Tapinoma tomentosa* (Fig. 111, worker major; antennæ broken off), from Mexico.

The tropical genus *Polyrhachis* includes, according to Smith, all those species that closely resemble *Formica*, but which

have the thorax and node of the peduncle armed with spines or hooks. They construct small semicircular nests, of a kind of net-work, on the leaves of trees and shrubs. Their communities are small, seldom exceeding twenty individuals. Mr. Norton describes *P. arboricola* (Fig. 112, worker major) from Mexico. An allied genus is *Ectatomma* (Fig. 113, worker major of *E. ferruginea* Norton, from Mexico).

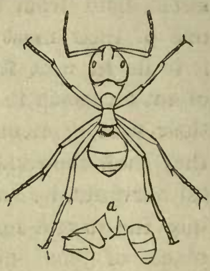


Fig. 112.

Mr. F. Smith has described a new genus, *Œcophylla*, which is allied to Formica. They are green ants, found building in trees in the tropics of the old world. The nest of *Œ. smaragdina* Smith is "formed by drawing together a number of green leaves, which they unite with a fine web. Some nests are a foot in diameter. They swarm, says Mr. Wallace, in hilly forests in New Guinea. Their sting is not very severe. This genus forms a link between Formica and Myrmica; it agrees with the former in having a single node to the peduncle, and with the latter in having the ocelli obsolete in the workers, and in being furnished with a sting."

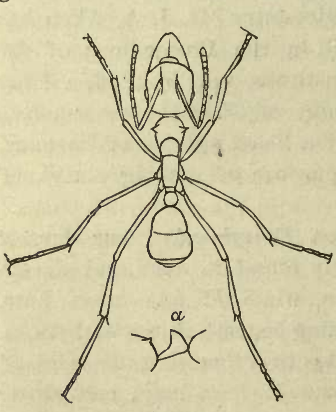


Fig. 113.

The curious Honey-ant of Texas and Mexico, *Myrmecocystus Mexicanus* Westwood, has two kinds of "workers of very distinct forms, one of the usual shape," according to Smith, "and performing the active duties of the formicarium; the other and larger worker is inactive and does not quit the nest, its sole purpose, apparently, being to elaborate a kind of honey, which they are said to discharge into prepared receptacles, which constitutes the food of the entire population of the community. In the honey-secreting workers the abdomen is distended into a large globose bladder-like form. From this honey an agreeable drink is made by the Mexicans."

The second subfamily, *Myrmicariæ*, includes those species in which the two first abdominal segments are contracted and lenticular. In *Myrmica* the females and workers are armed with spines, and the ocelli are absent in the workers. The species are very small, and mostly bright colored. *Myrmica molesta* Say is found in houses all over the world.

G. Lincecum describes the habits of the Agricultural Ant of Texas, *Myrmica molefaciens.* It lives in populous communities. "They build paved cities, construct roads, and sustain a large military force." In a year and a half from the time the colony begins, the ants previously living concealed beneath the surface, appear above and "clear away the grass, herbage, and other litter, to the distance of three or four feet around the entrance to their city, and construct a pavement, ... consisting of a pretty hard crust about half an inch thick," formed of coarse sand and grit. These pavements would be inundated in the rainy season, hence, "at least six months previous to the coming of the rain," they begin to build mounds rising a foot or more from the centre of the pavement. Within these mounds are neatly constructed cells into which the "eggs, young ones, and their stores of grain, are carried in time of rainy seasons." No green herb is allowed to grow on the pavement except a grain-bearing grass, Aristida stricta. This grain, when ripe, is harvested, and the chaff removed, while the clean grain is carefully stored away in dry cells. Lincecum avers that the ants even sow this grain. They also store up the "grain from several other species of grass, as well as seeds from many kinds of herbaceous plants."

Pheidole is distinguished by having workers with enormous heads. *P. notabilis* Smith, from the Island of Bachian, Indian Archipelago, is noted for the enormously enlarged, cubical head of the worker major, which is at least six times the size of the abdomen, while in the worker minor, the head is of the ordinary size. An Indian species, *P. providens* Westwood, according to Col. Sykes, "collects so large a store of grass seeds as to last from January and February, the time of their ripening, till October."

The genus *Atta* is also well-armed, while the workers have a very large, deeply incised and heart-shaped head, without

ocelli, and the second abdominal knot-like ring is very transverse. *A. clypeata* Smith is a Mexican species.

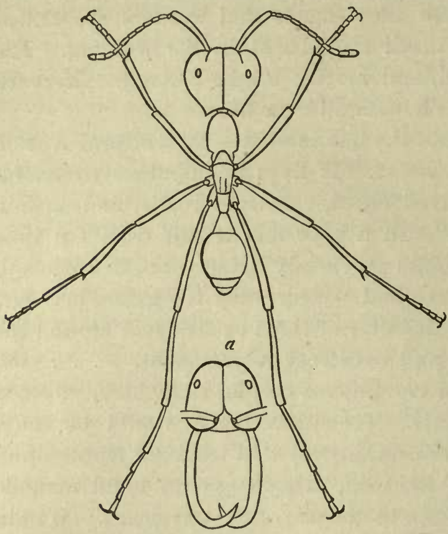


Fig. 114.

In *Eciton* the mandibles nearly equal the length of the insect itself. This genus is the most ferocious of all the ants, entering the nest of species of Formica and tearing them, limb from limb, and then carrying off the remains to their own houses.

Eciton Mexicana Roger (Fig. 114, worker major, *a*, front view of head, showing the immense sickle-like mandibles, and only the two basal joints of the antennæ; Fig. 115, worker minor, with a front view of the head, showing the mandibles of the usual size). This species, with *Eciton Sumichrasti* Norton, (Fig. 116, worker minor) has been found by Professor Sumichrast at Cordova and Orizaba, Mexico.

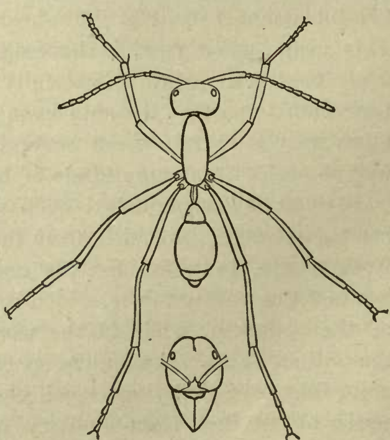


Fig. 115.

The males of Eciton are not yet known. Smith supposes that *Labidus* (a genus allied to Dorylus) is the male form, and Sumichrast thinks this conjecture is "sustained by the fact that it is in the season when the sorties of the Eciton are the more frequent that the Labidus also show themselves."

An allied genus is *Pseudomyrma*. *P. bicolor* Guérin (Fig. 117) is found in Central America. *P. flavidula* Smith, found in Central and South America, in Mexico lives, according to Sumichrast, within the spines which arm the stems of certain species of Mimosa. These spines, fixed in pairs upon the branches, are pierced near the end by a hole (Fig. 118*a*), which serves for the entrance and exit of the ants.

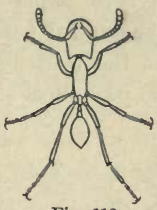


Fig. 116.

The genus *Œcodoma* differs from Atta in having the thorax armed with spines. *Œ. Mexicana* Smith (Figs. 119, female; 120, worker major) is abundant on the Gulf Coast of Mexico. In many places, according to Sumichrast, the natives eat the females after having detached the thorax. The intelligence of these ants is wonderful. They are seen in immense numbers transporting leaves. Sumichrast states that "the ground at the foot of the tree, where a troop of these '*arrieras*,' or workers, is assembled for despoiling it of its leaves, is ordinarily strewn with fragments cut off with the greatest precision. And if the tree is not too lofty, one can satisfy himself that a party of foragers, which have climbed the tree, occupies itself wholly in the labor of *cutting them off*, while at the foot of the tree are the *carriers* which make the journeys between the tree and the nest. This management, which indicates among these insects a rare degree of intelligence, is, perhaps, not a constant and invariable practice, but it is an incontestable fact, and one which can be constantly proved."

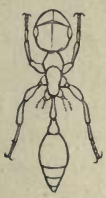


Fig. 117.

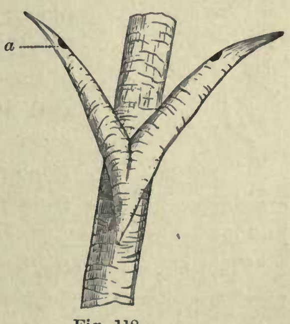


Fig. 118.

"It is specially in the argillaceous countries that the Œcodomas build their enormous formicaries, so that one perceives them from afar by the projection which they form above the level of the soil, as well as by the absence of vegetation in their immediate neighborhood. These nests occupy a surface of many square

metres,* and their depth varies from one to two metres. Very many openings, of a diameter of about one to three inches, are contrived from the exterior, and conduct to the inner cavities which serve as storehouses for the eggs and larvæ. The central part of the nest forms a sort of funnel, designed for the drainage of water, from which, in a country where the periodical rains are often abundant, they could hardly escape without being entirely submerged, if they did not provide for it some outlet.

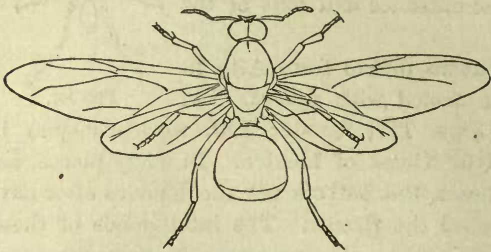


Fig. 119.

"The system which reigns in the interior of these formicaries is extreme. The collection of vegetable debris brought in by the workers is at times considerable; but it is deposited there in such a manner as not to cause any inconvenience to the inhabitants, nor impede their circulation. It is mostly leaves which are brought in from without, and it is the almost exclusive choice of this kind of vegetation which makes the *Œcodoma* a veritable scourge to agriculture. At each step, and in almost every place in the elevated woods, as on the plains; in desert places as well as in the neighborhood of habitations, one meets numerous columns of these insects, occupied with an admirable zeal in the transportation of leaves. It seems even that the great law of the *division of labor* is not ignored by these little creatures, judging from the observations which I have often had occasion to make." (Sumichrast.)

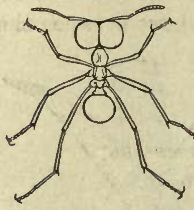


Fig. 120.

"The *Œ. cephalotes*," says H. W. Bates, "from its immense numbers, eternal industry, and its plundering propensities, becomes one of the most important animals of Brazil. Its immense hosts are unceasingly occupied in defoliating trees, and those most relished by them are precisely the useful kinds. They

* A metre is about thirty-nine (39.37) inches.

have regular divisions of laborers, numbers mounting the trees and cutting off the leaves in irregularly rounded pieces the size of a shilling, another relay carrying them off as they fall." "The heavily laden fellows, as they came trooping in, all deposited their load in a heap close to the mound. About the mound itself were a vast number of workers of a smaller size. The very large-headed ones were not engaged in leaf-cutting, nor seen in the processions, but were only to be seen on disturbing the nest." Bates also says, "I found, after removing a little of the surface, three burrows, each about an inch in diameter; half a foot downward, all three united in one tubular burrow about four inches in diameter. To the bottom of this I could not reach when I probed with a stick to the depth of four or five feet. This tube was perfectly smooth and covered with a vast number of workers of much smaller size than those occupied in conveying the leaves; they were unmixed with any of a larger size. Afterwards, on probing lower into the burrow, up came, one by one, several gigantic fellows, out of all proportion, larger than the largest of those outside, and which I could not have supposed to belong to the same species. Besides the greatly enlarged size of the head, etc., they have an ocellus in the middle of the forehead; this latter feature, added to their startling appearance from the cavernous depths of the formicarium, gave them quite a Cyclopean character."

Of another species, the *Œc. sexdentata*, Mr. Smith quotes from Rev. Hamlet Clark, that at Constancia, Brazil, the proprietor of a plantation used every means to exterminate it and failed. "Sometimes in a single night it will strip an orange or lemon tree of its leaves; a ditch of water around his garden, which quite keeps out all other ants, is of no use. This species carries a mine under its bed without any difficulty. Indeed, I have been assured again and again, by sensible men, that it has undermined, in its progress through the country, the great river Paraiba. At any rate, without anything like a natural or artificial bridge, it appears on the other side and continues its course." This testimony is confirmed by Mr. Lincecum (Proceedings of Academy of Natural Sciences, Philadelphia, 1867, p. 24) in an interesting account of the *Œc. Texana*, which he has observed for eighteen years. He states

that they often carry their subterranean roads for several hundred yards in grassy districts, where the grass would prove an impediment to their progress. On one occasion, to secure access to a gentleman's garden, where they were cutting the vegetables to pieces, they tunnelled beneath a creek, which was at that place fifteen or twenty feet deep, and from bank to bank about thirty feet. He also observes that the smaller workers which remain around the nest do not seem to join in cutting or carrying the leaves, but are occupied with bringing out the sand, and generally work in a lazy way, very differently from the quick, active leaf-cutters. Also, that the pieces of leaves are usually dried outside before being carried in, and that if wet by a sudden shower are left to decay without. He also thinks that their lives are dependent upon access to water, and that they always choose places where it is accessible by digging wells. In one case, a well was dug by Mr. Pearson for his own use, and water found at the depth of thirty feet. The ant-well which he followed was twelve inches in diameter." (Norton, American Naturalist, vol. 2.)

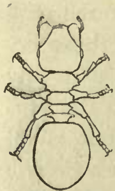


Fig. 121.

The genus *Cryptocerus* is remarkable for its flattened head, with the sides expanded into flattened marginal plates, concealing, or partly hiding the eyes. *C. multispinosus* Norton (Fig. 121) is the most common species about Cordova, Mexico, where they live, according to Sumichrast, within the trunks of trees.

Chrysididæ Latreille. In this small group the thirteen-jointed antennæ are elbowed, the eyes are oval and the ocelli distinct. The maxillary palpi are five, and the labial palpi three-jointed. There are about four hundred species known.

These insects are very different from the ants in their oblong compact form, their nearly sessile, oblong abdomen, having only three to five rings visible, the remaining ones being drawn within, forming a long, large, jointed sting-like ovipositor, which can be thrust out like a telescope. The abdomen beneath is concave, and the insect can roll itself into a ball on being disturbed. They are green or black. The sting has no poison-bag, and in this respect, besides more fundamental characters,

the Chrysis family approaches the Ichneumons. They best merit the name of "Cuckoo-flies," as they fly and run briskly in hot sunshine, on posts and trees, darting their ovipositor into holes in search of the nests of other Hymenoptera, in which to lay their eggs. Their larvæ are the first to hatch and devour the food stored up by other fossorial bees and wasps. "St. Fargeau, however, who has more carefully examined the economy of these insects, states that the eggs of the Chrysis does not hatch until the legitimate inhabitant has attained the greater part of its growth as a larva, when the larva of the Chrysis fastens on its back, sucks it, and in a very short time attains its full size, destroying its victim. It does not form a cocoon, but remains a long time in the pupa state." (Westwood.)

"In the Entomological Magazine has been noticed the discovery of Hedychrum bidentulum, which appears to be parasitic upon Psen caliginosus; the latter insect had formed its cells in the straws of a thatched arbor, as many as ten or twelve cells being placed in some of the straws. Some of the straws, perhaps about one in ten, contained one or rarely two, of the Hedychrum, placed indiscriminately amongst the others. Walkenaer, in his Memoirs upon Halictus, informs us that Hedychrum lucidulum waits at the mouth of the burrows of these bees, in order to deposit its eggs therein; and that when its design is perceived by the bees, they congregate together and drive it away. St. Fargeau states that the females of Hedychrum sometimes deposit their eggs in galls, while H. regium oviposits in the nest of Megachile muraria; and he mentions an instance in which the bee, returning to its nearly finished cell, laden with pollen paste, found the Hedychrum in its nest, which it attacked with its jaws; the parasite immediately, however, rolled itself into a ball, so that the Megachile was unable to hurt it; it, however, bit off its four wings which were exposed, rolled it to the ground and then deposited its load in the cell, and flew away, whereupon the Hedychrum, now being wingless, had the persevering instinct to crawl up the wall to the nest, and there quietly deposit its egg, which it placed between the pollen paste and the wall of the cell, which prevented the Megachile from seeing it." (Westwood.)

In *Cleptes* the underside of the abdomen is not hollowed out;

it is acutely oval, and with five rings in the male. *Cleptes semiaurata* Latr. is found in Central Europe. We have no native species. In *Chrysis* and the other genera, Stilbum, Parnopes, and Hedychrum, the abdomen is hollowed beneath, and the tip is broad and square. *Chrysis hilaris* Dahlb. (Fig. 122) is a short, thick, bluish green species, .32 inch in length. It is not uncommon in New England.

In *Hedychrum* the maxillary palpi and ligula are rather short, the last cordate; the mandibles are three-toothed within. The abdomen is broad and short, almost spherical, the second segment being the largest. *H. dimidiatum* Say is found in the Middle States.

The European *Stilbum splendidum*, Fabr. according to Dufour, lives in the cells of Pelopæus spirifex. It makes oblong cocoons of a deep brown, with rounded ends; they are of great tenacity, being mixed with a gummy matter.

Fig. 122.

Mr. Guenzius states that in Port Natal "a species of *Stilbum* lays its eggs on the collected caterpillars stored up by Eumenes tinctor, which constructs a nest of mud and attaches it to reeds, etc., not in a single, but a large mass, in which cells are excavated, similar to the nest of Chalicodoma micraria?* First, it uses its ovipositor as a gimlet, and when its point has a little penetrated, then as a saw or rasp; it likewise feels with its ovipositor, and, finding an unfinished or an empty cell it withdraws it immediately, without laying an egg."

ICHNEUMONIDÆ Latreille. The Ichneumon-flies are readily recognized by the usually long and slender body, the long exserted ovipositor, which is often very long, and protected by a sheath formed of four stylets of the same length as the true ovipositor. The head is usually rather square, with long, slender, many-jointed antennæ which are not usually elbowed. The maxillary palpi are five to six-jointed, while the labial

* A query (?) after the name of a species indicates a doubt whether the insect really belongs to that species; so with a ? after the name of a genus. A ? before both the genus and species expresses a doubt whether that be the insect at all.

palpi are three to four-jointed. The abdomen is inserted immediately over the hind pair of trochanters, and usually consists of seven visible segments. The fore-wings have one to three subcostal (cubital) cells.

The larva is a soft, fleshy, cylindrical, footless grub, the rings of the body being moderately convex, and the head rather smaller than in the foregoing families. The eggs are laid by the parent either upon the outside or within the caterpillar, or other larva, on which its young is to feed. When hatched it devours the fatty portions of its victim which dies gradually of exhaustion. The ovipositor of some species is very long, and is fitted for boring through very dense substances; thus Mr. Bond, of England, observes that *Rhyssa persuasoria* actually bores through solid wood to deposit its eggs in the larvæ of Sirex; the ovipositor is worked into the wood like an awl. When about to enter the pupa state the larva spins a cocoon, consisting in the larger species of an inner dense case, and a looser, thinner, outer covering, and escapes as a fly through the skin of the caterpillar. The cocoons of the smaller genera, such as Cryptus and Microgaster, may be found packed closely in considerable numbers, side by side, or sometimes placed upright within the body of caterpillars.

The Ichneumon-flies are thus very serviceable to the agriculturist, as they must annually destroy immense numbers of caterpillars. In Europe over 2,000 species of this family have been described, and it is probable that we have an equal number of species in America; Gerstaecker estimates that there are 4,000 to 5,000 known species.

The Ichneumons also prey on certain Coleoptera and Hymenoptera, and even on larvæ of *Phryganidæ*, which live in the water. In Europe, Pimpla Fairmairii is parasitic on a spider, Clubione holosericea, according to Laboulbène. Boheman states that P. ovivora lives on a spider, and species of Pimpla and Hemiteles were also found in a nest of spiders, according to Gravenhorst. Bouché says that Pimpla rufata devours, during winter and spring, the eggs of Aranea diadema, and Ratzburg gives a list of fourteen species of Ichneumons parasitic on spiders, belonging to the genera Pimpla, Pezomachus, Pteromalus, Cryptus, Hemiteles, Microgaster, and Mesochorus. Mr.

Emerton informs me that he has reared a Pezomachus from the egg-sac of Attus, whose eggs it undoubtedly devours. They are not even free from attacks of members of their own family, as some smaller species are well known to prey on the larger.

Being cut off from communication with the external world, the Ichneumon larva breathes by means of the two principal tracheæ, which terminate in the end of the body, and are placed, according to Gerstaecker, in communication with a stigma of its host. From the complete assimilation of the liquid food, the intestine ends in a *cul de sac*, as we have seen it in the larvæ of Humble-bees and of Stylops, and as probably occurs in most other larvæ of similar habits, such as young gall-flies, weevils, etc., which live in cells and do not eat solid food.

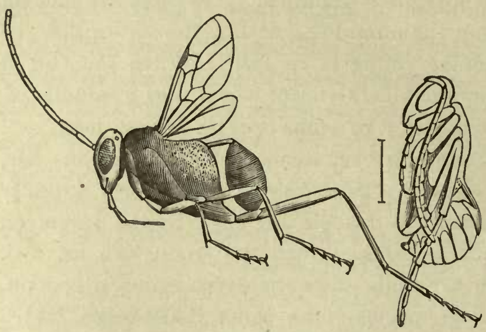


Fig. 123.

The first subfamily, the *Evaniidæ*, are insects of singular and very diverse form, in which the antennæ are either straight or elbowed, and thirteen to fourteen-jointed; the fore-wings have one to three subcostal (cubital) cells, and the hind wings are almost without veins.

In *Evania* and *Fœnus* the abdomen has a very slender pedicel, originating next the base of the metanotum. The former genus has a remarkably short triangular compressed abdomen in the female, but ovate in the male. The species are parasitic on Blatta and allies. *Evania lævigata* Olivier (Fig. 123, ♂ and pupa) is a black species, and is parasitic on the cockroach, Periplaneta, from the eggs of which we have taken the pupa and adult. The eggs of the cockroach are just large enough to accommodate a single Evania. This species

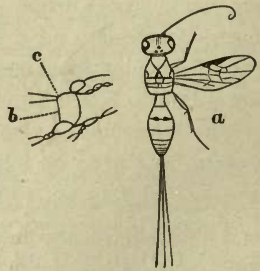


Fig. 124.

is widely distributed, and in Cuba, according to Cresson, it devours the eggs of Periplaneta Americana.

The genus *Aulacodes* of Cresson, "forms a very close connecting-link between the minute Ichneumons and the Evaniæ." *A. nigriventris* Cresson (Fig. 124, *a; b*, metathorax; *c*, insertion of the abdomen) lives in Cuba.

Fœnus is quite a different genus, as the abdomen is very long and slender. *Fœnus jaculator* Linn. is known in Europe to frequent the nests of *Crabronidæ*, ovipositing in the larvæ.

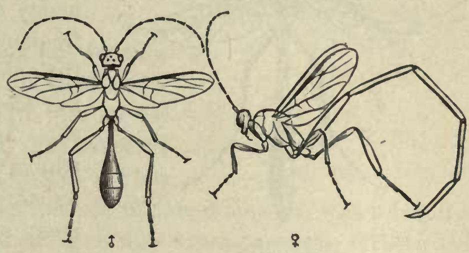


Fig. 125.

Pelecinus is a familiar insect, the immensely elongated, linear abdomen of the female easily distinguishing it. The male is extremely rare; its abdomen is short and clavate. It strikingly resembles Trypoxylon, though the abdomen is considerably larger. *Pelecinus polycerator* Drury (Fig. 125, ♂ and ♀) is widely distributed throughout this country.

The genuine *Ichneumonidæ* have long, straight, multiarticulate antennæ. The first subcostal (cubital) cell of the fore-wings is united with the median cell lying next to it, while the second is very small or wholly wanting. There are two recurrent veins. Mr. Cresson has described the genus *Eiphosoma* (Fig. 126), which he states may be known by the long, slender, compressed abdomen, and the long posterior legs, with their femora toothed beneath the tips. *E. annulatum* Cresson, a Cuban species, is, according to Poey, "parasitic upon a larva of Pyralis." (Cresson.)


Fig. 126.

In *Ophion* the antennæ are as long as the body, the abdomen is compressed, and the species are honey-yellow in color. *O. macrurum* Linn. (Fig. 127) attacks the American Silkworm, Telea Polyphemus. *Anomalon* is a larger insect and usually black. *A. vesparum* is, in Europe, parasitic on Vespa.

The genus *Rhyssa* contains our largest species, and frequents the holes of boring insects in the trunks of trees, inserting its remarkably long ovipositor in the body of the larvæ deeply embedded in the trunk of the tree. Harris states that *Rhyssa* (Pimpla) *atrata* and *lunator* (Fig. 128, male) of Fabricius, "may frequently be seen thrusting their slender borers, measuring from three to four inches in length, into the trunks of trees inhabited by the grubs of the Tremex, and by other wood-eating insects; and, like the female Tremex, they sometimes become fastened to the trees, and die without being able to draw their borers out again." The abdomen of the male is very slender.

Fig. 127.

Pimpla has the ovipositor half as long as the abdomen. *P. pedalis* Cresson is a parasite on Clisiocampa.

The genus *Trogus* leads to Ichneumon. The antennæ are shorter than the body; the abdomen is slightly petiolate, fusiform, and the second subcostal cell is quadrangular. *Trogus exesorius* Brullé is tawny red, and is a parasite of Papilio Asterias.

Fig. 128.

The genus *Ichneumon* (Fig. 129) is one of great extent, probably containing over three hundred species. The abdomen is long and slender, lanceolate ovate, slightly petiolate. The second subcostal cell is five-sided, and the ovipositor is either concealed or slightly exserted. *Ichneumon suturalis* Say is a very common form, and has been reared in abundance from the larva of the Army-worm, Leucania unipuncta. The body is pale rust-red, with black sutures on the thorax. Another common species, also parasitic on the

Army-worm, is the *Ichneumon paratus*, which is blackish, banded and spotted with yellow.

The singular genus *Grotea*, established by Mr. Cresson, has a long and narrow thorax (Fig. 130 *a*), and a very long and petiolated abdomen (*c*). We have taken *G. anguina* Cresson, the only species known, from the cells of Crabro in raspberry stems received from Mr. Angus.

Fig. 129.

Cryptus is a genus of slender form, with a long, cylindrical abdomen, which is petiolate. In the female it is oval with an exserted ovipositor. Cresson figures a wing (Fig. 131) of *C.? ornatipennis*, a Cuban species, which has the wings differently veined from the other species. Westwood remarks that in Europe a species of this genus preys on the larvæ of the *Ptinidœ*.

Pezomachus is usually wingless, and might at first sight readily be mistaken for an ant. The body is small, the oval abdomen petiolate, and the wings, when present, are very small. The species are very numerous. Gerstæcker suggests that some may be wingless females, belonging to winged males of allied genera.

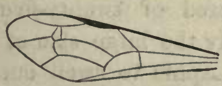


Fig. 131.

The third subfamily is the *Braconidœ*, containing those genera having long multiarticulate antennæ, and with the first subcostal cell separate from the first median, lying just behind it. The second subcostal cell is usually large, and there is only one recurrent vein.

The genus *Bracon* is distinguished by the deeply excavated clypeus. The first subcostal cell is completely formed behind, wanting the recurrent nerve; the second cell is long, and four-sided. More than five hundred species, mostly of bright, gay colors, are already known. The genus *Rhopalosoma* of Cresson connects Bracon and other minute genera (Braconidæ) with the true Ichneumons. *R. Poeyi* Cresson (Fig. 132) is a

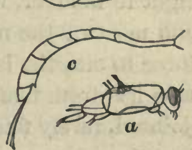


Fig. 130.

pale honey-yellow species, with a long club-shaped abdomen. It lives in Cuba.

Rogas is a genus differing from Bracon in having the three first abdominal rings long, forming a slender petiole.

In *Microgaster*, a genus containing numerous species, the antennæ are eighteen-jointed, and the abdomen is shorter than usual, and clavate. There are two or three subcostal cells, the second very small. *Microgaster nephoptericis* (Plate 3, figs. 3, 3 *a*) is parasitic on Nephopteryx Edmandsii, found in the cells of the Humble-bee.

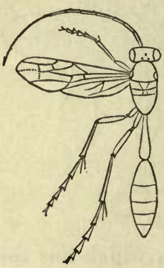


Fig. 132.

Aphidius, the parasite of the Plant-lice, is a most valuable ally of man. It is known by its small size, and by having the second and third segments of the abdomen moving free on each other. There are three cubital cells, though the wings are sometimes wanting. *Aphidius* (Praön) *avenaphis* of Fitch, the Oat-louse Aphidius, is black with honey-yellow legs, and is one-tenth of an inch long. *Aphidius* (Toxares) *triticaphis* Fitch, the Wheat-louse Aphidius, is black, shining, with thread-like antennæ composed of twenty-five joints. Its length is .08 inch. Frequently the large size of the parasite causes the body of the dead Aphis to swell out into a globular form.

Proctotrypidæ (*Proctotrupii*) Latreille. Egg-parasites. In this family are placed very minute species of parasitic Ichneumon-like Hymenopters which have rather long and slender bodies, with straight or elbowed antennæ of various lengths, often haired on the joints, usually ten to fifteen, sometimes only eight in number, while the wings are covered with minute hairs and most of the nervures are absent. The maxillary palpi are three to six, the labial palpi usually three-jointed. The abdomen has from five to seven joints, and the tarsi are mostly five-jointed, rarely four-jointed. These insects are often so minute that they can scarcely be distinguished by the naked eye unless it is specially trained; they are black or brown, and very active in their habits. They may be swept off grass and herbage, from aquatic plants, or from hot sand-banks. They

prey on the wheat-flies by inserting their eggs in their larvæ, on gall-midges, and gall-flies, and on fungus-eating flies. In Europe, species of *Teleas* lay their eggs in those of other insects, especially butterflies and moths and hemipters, where they feed on the juices of the larvæ growing within the egg, coming out as perfect Ichneumons. We probably have many species of these insects in this country. They usually occur in great numbers where they are found at all. They are almost too small to pin, and if transfixed would be unfit for study, and should, therefore, be gummed on mica, or put into small vials with alcohol.

In *Proctotrupes* the antennæ are long, feathered, twelve-jointed. The fore-wings have the beginning of a cubital cell, and two longitudinal veins on the posterior half. The abdomen is spindle-shaped and very acutely pointed, the terminal joints being tubular in their arrangement, and thus, as Westwood states, approaching the *Chrysididæ*. An unknown species (Fig. 133) we have taken at the Glen, in the White Mountains.

Fig. 133.

The head of *Diapria* is horizontal and longer than broad; the ocelli are moved forward on to the front edge; the long, filiform antennæ have a projection on the under side, with the basal joint much elongated; in the male they are thirteen or fourteen-jointed, with one joint less in the female. The wings are without stigma or veins. The abdomen is long, oval, pedicelled. In Europe, *D. cecidomyiarum* Bouché is parasitic on the larvæ of Cecidomyia artemisiæ. Esenbeck considers that this genus is also parasitic on the earth-inhabiting *Tipulidæ*.

Gonatopus is a wingless genus, with the head very broad, transverse, and the front deeply hollowed out, while the ten-jointed antennæ are long, slightly clavate, and the thorax is much elongated, deeply incised, forming two knot-like portions. *Gonatopus lunatus* Esenbeck, found in Europe, is one and a half lines long.

Ceraphron has the antennæ inserted near the mouth; they are elbowed, and eleven-jointed in the male, and ten-jointed in the female. The abdomen has a very short pedicel. The fore-

wings have a very short, bent costal (radial) vein. *C. armatum* Say was described from Indiana.

The egg-parasite, *Teleas*, has the elbowed twelve-jointed antennæ inserted very near the front of the head, and slightly hairy and simple in the male, but in the female terminated in a six-jointed club. The thorax is short, the legs thickened and adapted for leaping, and the abdomen is pedicelled. Many species have been found in Europe. According to Westwood, "the type of this genus is the *Ichneumon ovulorum* of Linnæus (*Teleas Linnœi* Esenbeck), which Linnæus and De Geer obtained from the eggs of moths." It has been raised from the eggs of several *Bombycidœ*. "Bouché observed the female deposit an egg in each of the eggs of a brood of Bombyx neustria. He describes the larva as elliptical, white, shining, rugose, subincurved, and one-third of an inch long." (Westwood.)

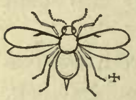


Fig. 134.

Of the extensive genus *Platygaster* over a hundred European species are already known. The body, especially the abdomen, is generally flattened, the antennæ are ten-jointed, and in the female clavate. The wing veins are absent; the rather slender legs are not adapted for leaping, and the tarsi are five-jointed. A species of Platygaster (Fig. 134) not yet named, oviposits in the eggs of the Canker-worm moth, Anisopteryx vernata, and by its numbers does much to check the increase of this caterpillar. We have seen several of these minute insects engaged in inserting their eggs into those of the Canker-worm.

Dr. Harris, in speaking of the enemies of the Hessian-fly, states, that "two more parasites, which Mr. Herrick has not yet described, also destroy the Hessian-fly, while the latter is in the flax-seed or pupa state. Mr. Herrick says, that the egg-parasite of the Hessian-fly is a species of Platygaster, that it is very abundant in the autumn, when it lays its own eggs, four or five together, in a single egg of the Hessian-fly. This, it appears, does not prevent the latter from hatching, but the maggot of the Hessian-fly is unable to go through its transformations, and dies after taking on the flax-seed form. Meanwhile its intestine foes are hatched, come to their growth, spin

themselves little brown cocoons within the skin of their victim, and in due time, are changed to winged insects, and eat their way out." *P. error* Fitch (Fig. 135) is closely allied to *P. tipulæ* Kirby, which, in Europe, destroys great numbers of the Wheat-midge. Whether this is a parasite of the midge, or not, Dr. Fitch has not yet determined.

The habits of the genus *Bethylus* remind us of the fossorial wasps. *Bethylus fuscicornis*, according to Haliday, "buries the larvæ of some species of Tinea, which feed upon the low tufts of Rosa spinosissima, dragging them to a considerable distance with great labor and solicitude, and employing, in the instance recorded by Mr. Haliday, the bore of a reed stuck in the ground instead of an artificial funnel, for the cells which should contain the progeny of the Bethylus, with its store of provision." (Westwood.)

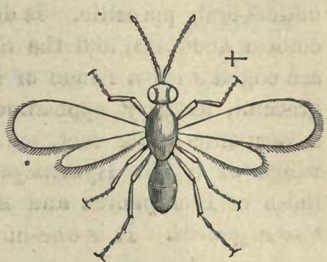


Fig. 135.

The genus *Inostemma* is remarkable for having the basal segment of the abdomen of the females furnished with a thick curved horn, which extends over the back of the thorax and head. Dr. Fitch states that *I. inserens* is supposed by Kirby to insert its eggs into those of the Wheat-midge. In the genus *Galesus* of Curtis, the mandibles are so enlarged and lengthened as to form a long beak, and Westwood farther states that in some specimens the anterior wings have a notch at the extremity. Say's genus *Coptera* has similar wings. *C. polita* Say was discovered in Indiana.

In the very minute species of *Mymar* and its allies, the head is transverse, with the antennæ inserted above the middle of the face; they are long and slender and elbowed in the male, but clavate in the female. There are no palpi, while the very narrow wings have a very short subcostal vein and on the edges are provided with long dense ciliæ. The antennæ of *Mymar* are thirteen-jointed in the male, and nine-jointed in the female; the club is not jointed. The tarsi are four-jointed, and the abdomen is pedunculated. *Mymar pulchellus* Curtis is a quarter of a line long. It is found in Europe. An allied

form *Polynema ovulorum* Linn. lays numerous eggs in a single butterfly's egg.

In *Anaphes* the male antennæ are twelve-jointed, those of the female nine-jointed, and the abdomen is subsessile and ovoid. In *Anagrus* the male antennæ are thirteen-jointed, those of the female nine-jointed, while the tarsi are four-jointed, and the acutely conical abdomen is sessile. No native species are known.

The smallest Hymenopterous insect known, if not the most minute of all insects, is the *Pteratomus Putnamii* Pack. (Plate 3, figs. 8, 8*a*, hind wing), which we first discovered on the body of an Anthophorabia in the minute eggs of which it is undoubtedly parasitic. It differs from Anagrus in the obtusely conical abdomen, and the narrower, very linear wings, which are edged with a fringe of long, curved hairs, giving them a graceful, feathery appearance. The fore-wings are fissured, a very interesting fact, since it shows the tendency of the wings of a low Hymenopterous insect to be fissured like those of Pterophorus and Alucita, the two lowest Lepidopterous genera. It is one-ninetieth of an inch in length.

CHALCIDIDÆ Westwood. This is a group of great extent; the species are of small size; they are often of shiny colors, as the name of the principal genus implies, being either bronzen or metallic. They have also elbowed antennæ with from six to fourteen joints, and the wings are often deficient in veins. In some genera, including Chalcis, the hind thighs are thickened for leaping. The differences between the sexes, generally very marked in Hymenoptera, are here especially so. The abdomen is usually seven-jointed in the male and six-jointed in the female, the other rings being aborted. The male of several species has the joints of the antennæ swelled and furnished with long hairs above. Some of the species of Pteromalus are wingless, and closely resemble ants. They infest eggs and larvæ. Some species prey upon the Aphides, others lay their eggs in the nests of wasps and bees. One species is known in Europe to be a parasite of the common house-fly. Others consume the larvæ of the Hessian-fly, and those Cecidomyiæ that produce galls, and also the true gall-flies (Cynips). Some are

parasites on other Ichneumon parasites, as there are species preying on the genus Aphidius, which is a parasite on the Aphis. Mr. Walsh has bred a species of Hockeria and of Glyphe, which are parasitic on a Microgaster, which in turn preys upon the Army-worm, Leucania unipuncta; and Chalcis albifrons Walsh, was bred from the cocoons of Pezomachus, an Ichneumon parasite of the same caterpillar.

The pupæ of some species are said to have the limbs and wings soldered together as in Lepidoptera, and the larvæ seldom spin a silken compact cocoon. We have probably in this country at least a thousand species of these small parasites, nearly twelve hundred having been named and described in Europe alone. They are generally large enough to be pinned or stuck upon cards or mica; some individuals should be preserved in this way, others, as wet specimens.

Fig. 136.

Chalcis is known by the abdomen having a long pedicel, its much thickened, oval thighs, and curved tibiæ. *Chalcis bracata* (Fig. 136), so named by Mr. Sanborn "in allusion to the ornamental and trousered appearance of the posterior feet" is about .32 inch in length. "Réaumur has described and figured a species of Chalcis, which is parasitic in the nest of the American wasp Epipone nitidulans and which he regarded as the female of that wasp." (Westwood.)

The genus *Leucospis* is of large size. It is known by having the large ovipositor laid upon the upper surface of the abdomen, and being spotted and banded with yellow, resembling wasps. One of our more common species is the *L. affinis* (Fig. 137) of Say. The Cuban *L. Poeyi* Guérin is parasitic on the Megachile Poeyi of Guérin.

Fig. 137.

The well-known Joint-worm, *Eurytoma*, is thought by many to produce galls on wheat-stems. The antennæ are, in the male, slender and provided with verticils of hairs. The acutely oval abdomen has a short pedicel. The hind legs are scarcely thicker than the fore limbs. *E. hordei* Harris (Fig. 138) is found in gall-like swellings of wheat-stalks. It is still a matter of discussion,

whether it directly produces the galls, or is parasitic, like many of the family, on other gall-insects. Dr. Harris, who has studied the habits of the Joint-worm, states that the body of the adult fly is jet black, and that the thighs, shanks (tibiæ), and claw-joints, are blackish, while the knees and other joints of the feet, are pale-yellow. The females are .13 inch long, while the males are smaller, have a club-shaped abdomen, and the joints of the antennæ surrounded with a verticil of hairs. The larva is described by Harris from specimens received from Virginia, as varying from one-tenth to nearly three-twentieths of an inch in length. It is of a pale yellowish white color, with an internal dusky streak, and is destitute of hairs. The head is round and partially retractile, with a distinct pair of jaws, and can be distinguished from the larvæ of the dipterous gall-flies by not having the v-shaped organs on the segment


Fig. 138.

succeeding the head. During the summer, according to Mr. Gourgas's observations reported by Dr. Harris, and when the barley or wheat is about eight or ten inches high, the presence of the young Joint-worms is detected "by a sudden check in the growth of the plants, and the yellow color of their leaves," and several irregular gall-like swellings between the second and third joints, or, according to Dr. Fitch, "immediately above the lower joint in the sheathing base of the leaf;" or, as Harris states, in the joint itself. The ravages of this insect have been noticed in wheat and barley. During November, in New England, the worms transform into the pupa state, according to the observations of Dr. A. Nichols, and "live through the winter unchanged in the straw, many of them in the stubble in the field, while others are carried away when the grain is harvested." In Virginia, however, the larva does not transform until late in February, or early in March, according to Mr. Glover. From early in May, until the first week in July, the four-winged flies issue from the galls in the dry stubble, and are supposed to immediately lay their eggs in the stalks of the young wheat or barley plants. The losses by this insect has amounted, in Virginia, to over a third of the whole crop. The best remedy

against the attacks of this insidious foe, is to burn the stubble in the autumn or spring for several successive years. Ploughing in the stubble does not injure the insects, as they can work their way out of the earth.

It has been objected by Westwood, Ratzburg, and more recently by Mr. Walsh, in the Practical Entomologist, vol. i, that as all the species of this family, so far as known, are parasitic, the Eurytoma cannot be a gall-producer, and that the galls are made by a dipterous insect (Cecidomyia) on which the Eurytoma is a parasite; but, as they offer no new facts to support this opinion, we are inclined to believe from the statements of Harris, Fitch, Cabell, T. Glover (Patent Office Report for 1854), and others, that the larva of the Eurytoma produces the gall. We must remember that the habits of comparatively few species of this immense family have been studied; that the genus Eurytoma is not remotely allied to the Cynipidæ, or true gall-flies (which also comprise animal parasites), in which group it has actually been placed by Esenbeck, for the reason that in Europe "several species of Eurytoma have been observed to be attached to different kinds of galls." (Westwood.) Dr. Fitch also describes the Yellow-legged Barley-fly, *Eurytoma flavipes*, which produces similar galls in barley, and differs from the Wheat Joint-worm in having yellow legs, while the antennæ of the male are not surrounded with whorls of hair. The *Eurytoma secalis* Fitch infests rye. It differs from E. hordei in "having the hind pair of shanks dull pale-yellow, as well as the forward ones." We shall also see beyond that several species of Saw-flies produce true galls, while other species of the same genus are external feeders, which reconciles us more easily to the theory that the Eurytoma hordei, and the other species described by Dr. Fitch, differ in their habits from others of the family, and are not animal parasites. Indeed the Joint-worm is preyed upon by two Chalcid parasites, for Harris records finding the larvæ, probably of Torymus, feeding on the Eurytoma larvæ, and that a species of Torymus (named T. Harrisii, by Dr. Fitch, and perhaps the adult of the first-named Torymus) and a species of Pteromalus are parasites on Eurytoma.

In *Monodontomerus* (Torymus) the third joint of the an-

tennæ is minute, and the hind femora are thick, but not serrated, and beneath armed with a tooth near the tip.

The wings are rudimentary so that it does not quit the cell. Newport states that the larva is flat, very hairy, and spins a silken cocoon when about to pupate. It is an "external feeding parasite" consuming the pupa as well as the larva of Anthophorabia. The imago appears about the last of June, perforating the cell of the bee. It also lives in the nests of Osmia, Anthophora, and Odynerus.

The genus *Anthophorabia* is so-called from being a parasite on Anthophora. The males differ remarkably from the females, especially in having simple instead of compound eyes, besides the usual three ocelli. *A. megachilis* Pack. (Plate 4; fig. 7, larva; 7 *a*, pupa) is a parasite on a species of Megachile. The larva is white, short and thick, cylindrical, with both extremities much alike; the segments are slightly convex, and the terminal ring is orbicular and rather large. Length, .04 inch, being one-third as broad as long. On opening the cells of Megachile, we found nearly a dozen containing these parasites, of which 150 larvæ were counted clustering on the outside of a dead and dry Megachile larva. In England they occur, according to Newport's observations, in much less numbers, as he found from thirty to fifty in a cell of Anthophora. A few females hatched out in the middle of October, and there were a few pupæ left, but the majority wintered over in the larva state, and a new and larger brood appeared in the spring.

Perilampus is a beautiful genus, with its shining, metallic tints. The eleven-jointed antennæ are short, lying when at rest in a deep frontal furrow. The head is large, while the abdomen is slightly pedicelled, being short, contracted, with the ovipositor concealed. *P. platygaster* Say and *P. triangularis* Say were described from Indiana.

The numerous species of *Pteromalus* often oviposit in the larvæ of butterflies. In this genus the antennæ are inserted in the middle of the front. The abdomen is nearly sessile, obtusely triangular, or acutely ovate in form, with the ovipositor concealed. The femora are slender. There are about three hundred species known to inhabit Europe. *Pteromalus vanessæ* Harris is a parasite on Vanessa Antiopa. *P. clisio-*

campæ Harris infests Clisiocampa. "*Pteromalus apum* is parasitic in the nests of the Mason-bee." (Westwood.) A species of this or an allied genus (Fig. 139) infests the eggs of the Clisiocampa Americana. Its eggs are probably laid within those of the Tent-caterpillar moth early in the summer, hatching out in the autumn, and late in the spring or early in June.

Fig. 139.

An allied genus, *Siphonura*, is a parasite on galls. It resembles a beetle, Mordella, from its very peculiar scutum.

The antennæ of Semiotellus are twelve-jointed. *S.* (Ceraphron) *destructor* Say (Fig. 140), according to that author, destroys the Hessian-fly, while lying in the "flax-seed" state. Fitch describes it as being a tenth of an inch long, black, with a brassy green reflection on the head and thorax, while the legs and base of the abdomen are yellowish.

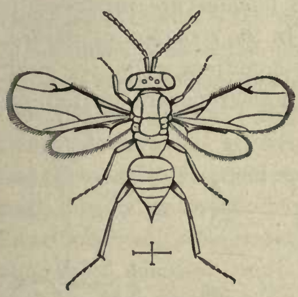


Fig. 140.

In *Encyrtus*, which comprises over a hundred species already known, usually rather small in size, the body is short and rounded. The eleven-jointed antennæ are inserted near the mouth. The thorax is square behind, and the sessile abdomen is short and broad at the base. *Encyrtus Bolus* and *E. Reate* are described from North America by Mr. F. Walker. *Encyrtus varicornis* is in Europe found as a parasite in the cells of Eumenes coarctata.

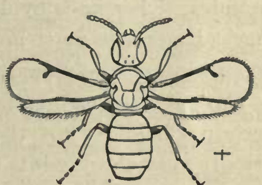


Fig. 141.

The antennæ of *Eulophus* are nine-jointed, with a long branch attached to the third, fourth, and fifth joints. The abdomen is flattened, sessile. *E. basalis* Say was described from Indiana. We figure a Chalcid (Fig. 141, ♂), allied to Eulopus, which preys upon the American Tent Caterpillar.

A species of *Blastophaga* (B. grossorum Grav.) is interesting as it is the means of assisting in the fertilization of the Fig

blossoms, which act, as applied to this instance of the fertilization of flowering plants by insects, has been called by Mr. Westwood "caprification."

Cynipidæ Westwood. (*Diplolepariæ* Latreille.) Gall-flies. In this most interesting family we have a singular combination of zoölogical and biological characters. The gall-flies are closely allied to the parasitic Chalcids, but in their habits are plant-parasites, as they live in a gall or tumor formed by the abnormal growth of the vegetable cells, due to the irritation first excited when the egg is laid in the bark, or substance of the leaf, as the case may be. The generation of the summer broods is also anomalous, but the parthenogenesis that occurs in these forms, by which immense numbers of females are produced, is necessary for the work they perform in the economy of nature. When we see a single oak hung with countless galls, the work of a single species, and learn how numerous are its natural

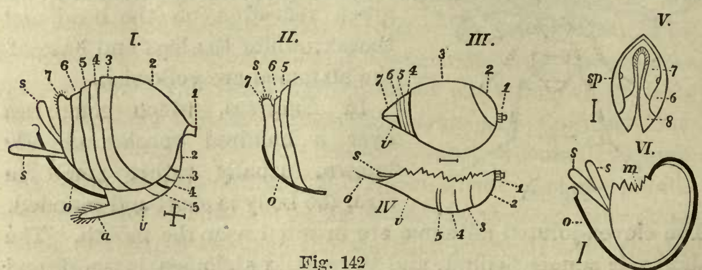


Fig. 142

enemies, it becomes evident that the demand for a great numerical increase must be met by extraordinary means, like the generation of the summer broods of the Plant-lice.

The gall-flies are readily recognized by their resemblance to certain Chalcids, but the abdomen is much compressed, and usually very short, while the second, or the second and third segments, are greatly developed, the remaining ones being imbricated or covered one by the other, leaving the hind edges exposed. Concealed within these, is the long, partially coiled, very slender ovipositor, which arises near the base of the abdomen.* Among other distinguishing characters, are the straight

* Fig. 142. I, abdomen of *Cynips quercus-aciculata* Osten Sacken, with the ovipositor exserted; II, the same with the ovipositor retracted; III, the abdomen of the female of *Figites* (Diplolepis) 5-*lineatus* Say; IV, the same showing the ventral portion, in nature covered by the tergal portion of the abdomen; V, end view of the

(not being elbowed) thirteen to sixteen-jointed antennæ, the labial palpi being from two to four-jointed, and the maxillary palpi from four to six-jointed. The maxillary lobes are broad and membranous, while the ligula is fleshy, and either rounded or square at the end. There is a complete costal cell, while the subcostal cells are incomplete. The egg is of large size, and increases in size as the embryo becomes more developed. The larva is a short, thick, fleshy, footless grub, with the segments of the body rather convex. When hatched they immediately attack the interior of the gall, which has already formed around them. Many species transform within the gall, while others enter the earth and there become pupæ.

It is well known that of many gall-flies the males have never been discovered. "Hartig says that he examined at least 15,000 specimens of the genus *Cynips*, as limited by him, without ever discovering a male. To the same purpose he collected about 28,000 galls of *Cynips divisa*, and reared 9,000 to 10,000 Cynips from them; all were females. Of *C. folii*, likewise, he had thousands of specimens of the female sex without a single male." (Osten Sacken.) Siebold supposes in such cases that there is a true parthenogenesis, which accounts for the immense number of females.

Baron Osten Sacken, however, thinks that these females are impregnated by males of the same species which are produced from a different sort of gall, existing, however, on the same species of tree. He reports in the Proceedings of the Academy of Natural Sciences of Philadelphia, July 1861, "an observation, which, if confirmed, would solve the question of the sexes of Cynipidæ. From a singular, spindle-shaped gall on the red oak, I reared a male Cynips, which is similar to the gall-fly, *Cynips confluens* Harris, of the common oak-apple of the red oak, known by the female sex only, and looks exactly as one might suppose the male *Cynips confluens*, if known, ought to look. If it is proved that the Cynips of the spindle-

abdomen of Cynips, showing the relations of segments 7-8, the sternal portion of the eighth segment being obsolete; *sp*, the single pair of abdominal spiracles; VI, terminal ventral piece, from which the sheaths (*s s*) and the ovipositor (*o*) take their origin; it is strongly attached at *m* to the tergites of the sixth and seventh rings; *o*, ovipositor; *s*, *s* its sheaths; *a*, an appendage to *v*, the terminal sternite. — *From Walsh.*

shaped gall is the male of the Cynips of the oak-apple, and if it is shown, by further observation, that in the genera, supposed to be agamous, by Hartig, the males produced from galls are different from those of the females, then it will be plain how 28,000 galls of the same kind could give 10,000 females and not a single male.

"A strong proof in confirmation of my assertion is, that in those genera, the males of which are known, both sexes are obtained from galls in almost equal numbers; even the males, not unfrequently, predominate in number (see Hartig, l. c. iv, 399). Now the gall-flies, reared by me from the oak-apple, were all females. Dr. Fitch, also, had only females; and Mr. B. D. Walsh, at Rock Island, Illinois, reared (from oak-apples of a different kind) from thirty-five to forty females, without a single male. This leads to the conclusion that the Cynips of the oak-apples belongs to the genera hitherto supposed to be agamous."

For an account of the habits and many other interesting points in the biology of these interesting insects, we further quote Baron Osten Sacken. "Most of the gall-flies always attack the same kind of oak; thus, the gall of *C. seminator* Harris, is always found on the white oak; *C. tubicola* Osten Sacken on the post oak, etc. Still, some galls of the same form occur on different oaks; a gall closely resembling that of *C. quercus-globulus* Fitch, of the white oak, occurs also on the post oak, and the swamp chestnut oak; a gall very similar to the common oak-apple of the red oak occurs on the black-jack oak, etc. Are such galls identical, that is, are they produced by a gall-fly of the same kind? I have not been able to investigate this question sufficiently. Again, if the same gall-fly attacks different oaks, may it not, in some cases, produce a slightly different gall? It will be seen below, that *C. quercus-futilis*, from a leaf-gall on the white oak, is very like *C. quercus-papillata* from a leaf-gall on the swamp-chestnut oak. I could not perceive any difference, except a very slight one in the coloring of the feet. Both gall-flies may belong to the same species, and although the galls are somewhat different, they are in some respects analogous, and might be the produce of the same gall-fly on two different trees.

"Some gall-flies appear very early in the season; *Cynips quercus-palustris* for instance, emerges from its gall before the end of May; these galls are the earliest of the season; they grow out of the buds and appear full grown before the leaves are developed. May not this gall-fly have a second generation, and if it has, may not the gall of this second generation be different from the first produced, as it would be under different circumstances, in a more advanced season, perhaps on leaves instead of buds, etc?

"A remarkable fact is the extreme resemblance of some of the parasitical gall-flies with the true gall-fly of the same gall. Thus, *Cynips quercus-futilis*, O. Sacken, is strikingly like Aulax? futilis, the parasite of its gall. The common gall on the blackberry stems produces two gall-flies which can hardly be told apart at first glance, although they belong to different genera." (Proceedings of the Entomological Society of Philadelphia.)

Hartig has divided this family into three sections: First, Cynips and its allies, the *true gall-flies* (Psenides) in which the second (counting the slender pedicel as the first) segment of the abdomen is longer than half its length, and the subcostal area is narrow, the basal areolet (cell) being opposite the base of the former.

Cynips confluens Harris forms the oak-apple commonly met with on the scrub-oak. There is a spring and summer brood. These galls, sometimes two inches in diameter, are green and pulpy at first, but when ripe have a hard shell with a spongy interior, in the centre of which, lodged in a woody kernel, which serves as a cocoon, the larva transforms, escaping through a hole, which it gnaws through both the kernel and shell. We have found the fly ready to escape in June, and Dr. Harris has found it in October. Two galls are represented on Plate 4, fig. 13; the larger of which has been tenanted, after the gall-flies had escaped, by an Odynerus. *Cynips gallæ-tinctoriæ* Olivier produces the galls of commerce, brought from Asia Minor.

Biorhiza (Apophyllus Hartig) is a wingless genus, and lives beneath the earth in galls formed at the roots of oak trees. *Biorhiza nigra* Fitch is black throughout, including the antennæ and feet, and is but .08 inch long.

Galls are often found on the blackberry, tenanted by another genus, *Diastrophus*, which has usually fifteen-jointed antennæ in the male, and one joint less in the female. On opening a gall containing this fly, we often find an inquiline gall-fly, Aulax, "showing the most striking resemblance in size, coloring and sculpture, to the Diastrophus, their companion. The one is the very counterpart of the other, hardly showing any differences, except the strictly generic characters." (Osten Sacken.) These galls are also infested by Chalcid parasites, Callimome (two species), Ormyrus, and Eurytoma.

Osten Sacken enumerates "eight cynipidous galls on the different kinds of roses of this country." The flies all belong to the genus *Rhodites*, which is distinguished by the under side of the last abdominal segment being drawn out into a long point, while the antennæ are fourteen-jointed in both sexes. *R. rosæ* produces the *bedeguar* gall ("from the Hebrew *bedeguach*, said to mean rose-apple"). It was formerly used as a medicine. The galls form a moss-like mass, encircling the rose branch. *Rhodites dichlocerus* of Harris (Fig. 143), produces hard, woody, irregular swellings of the branches.

Fig. 143.

We now come to the second section, the *Guest gall-flies* (Inquilinæ), which are unable to produce galls themselves, as they do not secrete the gall-producing poison, though possessing a well developed ovipositor. Hence, like the Nomada, etc., among bees, they are Cuckoo-flies, laying their eggs in galls already formed.

This group may generally, according to Mr. Walsh, be distinguished from the preceding by the sheaths of the ovipositor always projecting, more or less, beyond the "dorsal valve," which is a small, hairy tubercle at the top of the seventh abdominal segment. This dorsal valve also projects greatly. In almost all the species, the ovipositor projects from between the tips of the sheaths.

Among the Inquiline genera are *Synophrus*, *Amblynotus*, *Synerges*, and *Aulax*, which are guests of various species of Cynipides.

In *Figites* and allies (Figitidæ), the third section of the

family, the second segment is shorter than half the length of the abdomen, being much longer and less high and compressed than in the Cynipides, and the ovipositor is retracted within the abdomen. These insects are true internal parasites, resembling the Chalcids. *Ibalia* is a parasite on a wood-beetle. This genus has, by Walsh, been placed in the Cynipides. Figites has feather-like antennæ in the male; it is a parasite on the larvæ of Sarcophaga. The genus *Allotria* is a parasite on Aphis.

Walsh states that two genera, which he has identified as *Kleidotoma* and *Eucoila* are true *Figitidæ*, and "have the wings fringed like a *Mymar*, and the former has them emarginate at tip with the radial area in my species distinctly open, and the latter simple at tip with the radial area in my species marginally closed by a coarse brown vein." *Eucoila* is supposed to be parasitic on some insect attacking the turnip.

TENTHREDINIDÆ Leach. The Saw-flies connect the Hymenoptera with the Lepidoptera. In the perfect state they conform to the Hymenopterous type, but as larvæ they would often be mistaken for Lepidopterous larvæ, and in their habits closely resemble many caterpillars. The three divisions of the body, usually so trenchantly marked in the higher Hymenoptera, are here less distinct, since the abdomen is sessile, its basal ring being broad and applied closely to the thorax, while the succeeding rings are very equal in size. The head is broad and the thorax wide, closely resembling that of the Lepidoptera. The wings (Fig. 144, fore-wing) are larger in proportion to the rest of the body than usual; they are more net-veined, the cells being more numerous and extending to the outer margin.*

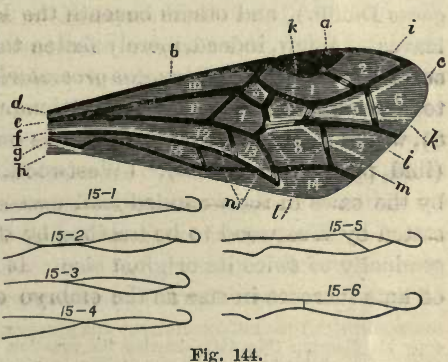


Fig. 144.

*In treating of this family we avail ourselves largely of the important work on the American species, publishing at the time of writing, by Mr. E. Norton, in the Transactions of the American Entomological Society, vols. 1, 2. We therefore

All these characters show that the saw-fly is a degraded Hymenopter.

The antennæ are not elbowed; are rather short and simple, clavate, but in rare instances fissured or feathered. The abdomen consists, usually, of eight external segments, the two last being aborted on the under side, owing to the great development of the ovipositor. The ovipositor or "saw" (compare Fig. 24) consists of two lamellæ, the lower edge of which is toothed and fits in a groove in the under side of the upper one, which is toothed above, both protected by the usual sheath-like stylets. On pressing, says Lacaze-Duthiers, the end of the abdomen, we see the saw depressed, leave the direction of the axis of the body, and become perpendicular. By this movement the saw, which both cuts and pierces, makes a gash in the soft part of the leaf where it deposits its eggs.

The eggs are laid more commonly near the ribs of the leaf, in a series of slits, each slit containing but a single egg. "Some species, on the other hand, introduce their eggs by means of their saws into the edges of leaves (*Nematus conjugatus* Dahlb.), and others beneath the longitudinal ribs of the leaves. A few, indeed, merely fasten their eggs upon the outer surface of the leaves (*Nematus grossulariæ*, etc.), attaching them together like a string of beads (Réaumur, vol. v, plate 10, fig. 8), whilst a few place them in a mass on the surface of the leaf (ibid, plate 11, figs. 8, 9)." (Westwood.) The irritation set up by the saws in the wounded leaf, causes a flow of sap which is stated by Westwood to be imbibed by the egg, so that it swells gradually to twice its original size. It is known that the egg of ants increase in size as the embryo develops, and we would

copy his diagram (Fig. 144), showing the venation of the wing (compare Fig. 29 and our nomenclature), with the explanation of parts given by him.

a, stigma; *b*, costa or costal margin; *c*, apical margin; *d*, costal and post-costal veins; *e*, externomedial; *f*, *g*, anal; *h*, posterior margin; *i*, marginal vein; *j*, submarginal vein; *k*, first, second, and third (transverse) submarginal nervures; *l*, recurrent nervures (discoidal); *m*, discoidal vein; *n*, first and second inner apical or submarginal nervures. Bullæ or clear spots, on the veins or nervures, with bullar or clear lines crossing them. 1, 2, marginal or radial cells; 3, 4, 5, 6, submarginal or cubital cells; 7, 8, 9, discoidal cells; 10, costal cell; 11, 12, brachial or medial cells; 13, 14, inner and outer apical cells. (Hinder cells, Hartig. Cellule du limbe, St. Farg.) No. 11 is sometimes the medial, and Nos. 12 and 13 the submedial cells; Nos. 9 and 14 the apical cells; Nos. 7 and 13 discoidal; Nos. 10, 11, 12, 15, the first, second, third and fourth brachial cells; 15, lanceolate cell. 1, open; 2, contracted; 3, petiolate; 4, subcontracted; 5, with oblique cross nervure; 6, with straight cross nervure.

question whether the increase in size of the eggs of the Saw-fly is not rather due to the same cause.

The punctures in the plant often lead, in some genera, to the production of galls, in which the larvæ live, thus showing the near relationship of this family to the gall-flies (Cynipidæ).

The larvæ strongly resemble caterpillars, but there are six to eight pairs of abdominal legs, whereas the caterpillar has but five pairs. Many species curl the hind body up spirally when feeding or at rest. They are usually green, with lines and markings of various colors. They usually moult four times, the last change being the most marked. Most of the larvæ secrete silk and spin a tough cocoon, in which they hibernate in the larva, and often in the pupa state. The pupa has free limbs, as in the other families. The eggs are usually deposited in the leaves of plants, but in a few cases, according to Norton, in slender or hollow stems. While some are slug-shaped, like the Pear-slug, others like *Lyda inanita*, mentioned by Westwood, live on rose bushes, and construct a "portable case, formed of bits of rose-leaves arranged in a spiral coil;" and other species are leaf-rollers, like the Tortricids. The larva of *Cephus* does injury to grain, in Europe, by boring within the stems of wheat. A remarkable instance of the care of the saw-fly for her young, is recorded by Mr. R. H. Lewis, who observed in Australia, the female of *Perga Lewisii* deposit its eggs in a slit next the midribs of an Eucalyptus leaf. They were placed transversely in a double series. "On this leaf the mother sits till the exclusion of the larvæ; and as soon as these are hatched, the parent follows them, sitting with outstretched legs over her brood, protecting them from the attacks of parasites and other enemies with admirable perseverance." (Westwood.)

The species are mostly limited to the temperate zone, but few being found in the tropics. The perfect insects mostly occur in the early summer, and are found on the leaves of the trees they infest, or feeding on flowers, especially those of the umbelliferous plants.

The genus *Cimbex* contains our largest species, the antennæ ending in a knob. *C. Americana* Leach is widely distributed, and varies greatly in color. The large whitish larva, with a

blackish dorsal stripe, may be found rolled up in a spiral on the leaves of the elm, birch, linden and willow trees. When disturbed it ejects a fluid from pores situated above the spiracles. It constructs a large tough parchment-like cocoon, and the fly appears in the early summer.

The genus *Trichiosoma* is recognized by its hairy body, and the antennæ have five joints preceding the three-jointed club. *T. triangulum* Kirby is found in British America and Colorado, and a variety, *T. bicolor* Harris, on Mount Washington; it is black, except the tip of the abdomen, with the fourth and fifth joints of the antennæ piceous, and the thorax is covered with ash-colored hair.

In *Abia* the antennæ are seven-jointed, with the club obtuse; the body is villose, the abdomen having a metallic silken hue. The *Abia caprifolium* Norton (Fig. 145, larva) is very destructive to the Tartarian Honeysuckle, sometimes stripping the bush of its leaves during successive seasons in Maine and Massachusetts. It hatches out and begins its ravages very soon after the leaves are out, eating circular holes in them. It lies curled up on the leaf and when disturbed emits drops of a watery fluid from the pores in the sides of the body, and then falls to the ground. During the early part of August it spins a pale yellowish silken cocoon, but does not change to a pupa, Mr. Riley states, until the following spring. He describes the larva as being common about Chicago; that it is "bluish green on the back, and yellow on the sides, which are pale near the spiracles, and covered with small black dots. Between every segment is a small, transverse, yellow band, with a black spot in the middle and at each end. Head free, of a brownish black above and color of the body beneath." The fly is described by Norton as being black, with faint greenish reflections on the abdomen; there are two white bands at the base of the metathorax, and the wings are banded. It is .36 inch long and the wings expand .70 inch. The larvæ can easily be destroyed from their

Fig. 145.

habit of falling to the ground when the bush is shaken, where they can be crushed by the foot. Dr. Fitch has reared *Abia cerasi* from one or two cocoons found on the wild cherry, the fly appearing in New York during March.

Hylotoma is a much smaller genus; the basal joint of the antenna is oval, while the second is small and round, and the terminal joint is very long. The larva is twenty-footed, and when eating curves the end of the body into the form of an S. The pupa is protected by a gauzy, doubly enveloping cocoon. *H. McLeayi* Leach is wholly black, sometimes with a tinge of blue. It is found throughout the Northern States.

The genus *Pristiphora*, closely allied to Nematus, is known by its nine-jointed antennæ, and the single costal cell; the first submarginal (subcostal) cell having two recurrent veinlets. *P. identidem* Norton has been discovered by Mr. W. C. Fish to be destructive to the cranberry on Cape Cod. He has reared the insect, and sent me the following notes on its habits, while the adult fly has been identified by Mr. Norton, to whom I submitted specimens. The larvæ were detected in the first week of June, eating the leaves; "they were light or pale yellowish green when first hatched," and grew darker with age. The head of the young was dark, but in the full-grown worm lighter. When full-grown they were about .30 of an inch in length, and had two lighter whitish green stripes running along the back from head to tail. They had spun their cocoons by the 20th of June in the rubbish at the bottom of the rearing bottles. On the 29th of June they came out in the perfect state. We would add to this description that the body, in two alcoholic specimens of the larvæ, was long, cylindrical, and smooth, with seven pairs of abdominal feet. The head is full, rounded and blackish, but after the last moult pale honey-yellow. The male is shining black, and Mr. Norton informs me that it is his *P. idiota*. *P. grossulariæ* Walsh is a widely diffused species in the Northern and Western States, and injures the currant and gooseberry. The female fly is shining black, while the head is dull yellow, and the legs are honey-yellow, with the tips of the six tarsi, and sometimes the extreme tips of the hinder tibiæ and of the tarsal joints pale dusky for a quarter of their length. The wings are partially hyaline, with black veins, a

honey-yellow costa, and a dusky stigma, edged with honey-yellow. The male differs a little in having black coxæ. Mr. Walsh states that the larva is a pale grass-green worm, half an inch long, with a black head, which becomes green after the last moult, but with a lateral brown stripe meeting with the opposite one on the top of the head, where it is more or less confluent; and a central brown-black spot on its face. It appears the last of June and early in July, and a second brood in August. They spin their cocoons on the bushes on which they feed, and the fly appears in two or three weeks, the specimens reared by him flying on the 26th of August. *P. sycophanta* Walsh is an "inquiline," or guest gall-saw-fly, inhabiting a Cecidomyian gall on a willow.

The genus *Euura* comprises several gall-making species. It differs from the preceding genus in the second, instead of the first, submarginal cell having two recurrent venules. Mr. Walsh has raised *E. orbitalis* Norton (E. genuina Walsh) from galls found on Salix humilis. This gall is a bud which is found enlarged two or three times its natural size, before it unfolds in spring. The larva is twenty-footed, is from .13 to .19 of an inch long, of a greenish white color, and the head is dusky. It bores out of its gall in autumn, descending an inch into the ground, where it spins a thin, silken, whitish cocoon. The gall of *E. salicis-ovum* Walsh is found on Salix cordata. The female is shining yellow, while the ground color of the male is greenish white. The gall of this species is an oval roundish, sessile, one-chambered, green or brownish swelling, .30 to .50 of an inch long, placed lengthwise on the side of small twigs. The larva is pale yellowish, and the fly appears in April. The fly is, according to Walsh, "absolutely undistinguishable by any reliable character from the guest gall-saw-fly, *Euura perturbans* Walsh," which inhabits dipterous galls made by Cecidomyian flies on the willow and grape (Walsh). If these two "species" do not differ from each other, either in the larva or adult state, "by any reliable characters," then one must question whether the variation in habits is sufficient to separate them as species, and whether E. salicis-ovum does not, sometimes, instead of forming a new gall, lay its eggs in a gall ready-made by a dipterous gall-fly. We have seen that Odynerus

albophaleratus, which usually makes a mud cell situated in the most diverse places, in one case at least, makes no cell at all, but uses the tunnel bored out by a Ceratina! and yet we should not split this species into two, on account of this difference in its habits. We had written this before meeting with Mr. Norton's remark that "it is difficult to give a hearty assent to Mr. Walsh's inquilines or guest-flies, without further investigation." (Transactions of the American Entomological Society, vol. i, p. 194.)

In *Nematus* the nine-jointed antennæ have the third joint longest. There is one costal and four subcostal cells, the second cell receiving two recurrent veinlets; the basal half of the lanceolate cell is closed; the hind wings have two middle cells, and the tibiæ are simple.

The larvæ are hairy with warts behind the abdominal feet. They have twenty feet, the fourth and eleventh segments (counting the head as one) being footless. They are either solitary, feeding upon the leaves of plants, or social and generally found on pine trees, while some species live in the galls of plants. The pupa, according to Hartig, is enclosed in an egg-shaped cocoon, like that of Lophyrus, but less firm, though with more outside silk. It is generally made in the earth, or in leaves which fall to the ground. *N. vertebratus* Say is green, with the antennæ and dorsal spots blackish, the thorax being trilineate. There are fifty species in this country, of which the most injurious one, the Gooseberry saw-fly, has been brought from Europe. This is the *N. ventricosus* Klug which was undoubtedly imported into this country about the year 1860, spreading mostly from Rochester, N. Y., where there are extensive nurseries. It does more injury to the currant and gooseberry than any other native insect, except the currant moth (Abraxas? tiliaria). Professor Winchell, who has studied this insect in Ann Arbor, Michigan, where it has been very destructive, observed the female on the 16th of June, while depositing her cylindrical, whitish and transparent eggs, in regular rows along the under side of the veins of the leaves, at the rate of about one in forty-five seconds. The embryo escapes from the egg in four days. It feeds, moults and burrows into the ground within a period of eight days. It remains thirteen days in the ground, being

most of the time in the pupa state, while the fly lives nine days. The first brood of worms appeared May 21, the second brood June 25. Winchell describes the larva as being pale-green, with the head, tail and feet, black, with numerous black spots regularly arranged around the body, from which arise two or more hairs. Figure 146, 1, shows the eggs deposited along the under side of the midribs of the leaf; 2, the holes bored by the very young larvæ, and 3, those eaten by the larger worms.

In transporting gooseberry and currant bushes, Walsh recommends that the roots be carefully cleansed of dirt, so that the cocoons may not be carried about from one garden to another. The leaves of the bushes should be examined during the last week of May, and as only a few leaves are affected at first, these can be detected by the presence of the eggs and the little round holes in them, and should be plucked off and burnt. The female saw-fly is bright honey-yellow, with the head black, but yellow below the insertion of the antennæ. The male differs in its black thorax, and the antennæ are paler reddish than in the female.*

Fig. 146.

The genus *Emphytus* has nine-jointed antennæ; the third

* Mr. Norton has communicated the following description of the larva of another saw-fly of this genus which infests the weeping-willow.

"*Nematus trilineatus* Norton. The larvæ of this were first seen upon the weeping-willows about August 1st, in immense numbers, almost wholly stripping large trees of their leaves. They begin upon the edge of the leaf and eat all of it except the inner midrib. They are very sensitive to disturbances, very lively, and are generally found with the hinder part of their bodies bent up over the back. They are twenty-footed, of a bright green color, palest at head and tail, with five rows of black dots down the back, the outer row upon each side irregular and with intervals. On each side above the feet is another row of larger black dots, and the three anterior pair of feet are black at the base, middle and tip.

"A great number of the saw-flies were found flying about the trees, August 19th, in the proportion of about ten males to one female. The males being almost wholly black upon the thorax."

and fourth joints of equal length; the wings have two subcostal and three median cells, the first as long as the second, generally longer; the first receiving one recurrent vein, the second two. We have found the larva of *E. maculatus* Norton on the cultivated strawberry, to which, in the Western States, it sometimes does considerable damage, but it can be quite readily exterminated by hand-picking. Mr. Riley has carefully observed the habits of this insect, and we condense the following remarks from his account in the *Prairie Farmer*:—Early in May, in Northern Illinois, the female saw-fly deposits her eggs in the stem of the plant. They are white and .03 of an inch long, and may be readily perceived upon splitting the stalk; though the outside orifice, at which they were introduced, is scarcely perceptible, their presence causes a swelling in the stalk. By the middle of May the worms will have eaten innumerable small holes in the leaves. They are dirty yellow and gray green, and at rest curl the abdomen up spirally. They moult four times, and are, when full-fed, about three-fourths of an inch in length. They make a loose, earthen cocoon in the ground, and change to perfect flies by the end of June and the beginning of July. A second brood of worms appear, and in the early part of August descend into the ground and remain in the larva state until the middle of the succeeding April, when they finish their transformations. The fly is pitchy black, with two rows of dull, dirty white, transverse spots upon the abdomen. The nine-jointed antennæ are black, and the legs are brown, and almost white at the joints. Fig. 147 represents the Strawberry Emphytus in all its stages of growth. 1, 2, ventral and side-view of the pupa; 3, the fly enlarged;

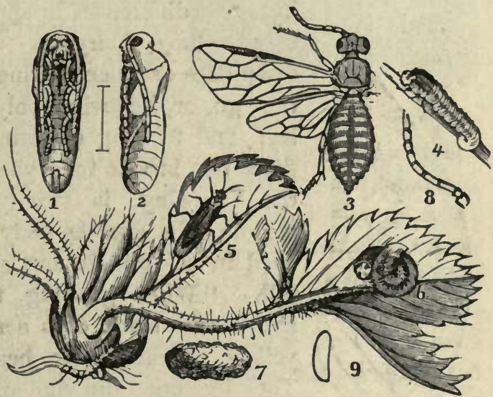


Fig. 147.

5, the same, natural size; 8, an antenna enlarged; 4, the larva while feeding; 6, the same, at rest; 7, the cocoon; 9, an egg enlarged.

Of the genus *Dolerus*, known by the second submarginal cell receiving two recurrents, *D. arvensis* Say, is a common blue-black species found in April and May on willows.

The genus *Selandria* is the most injurious genus of the family. It embraces the Pear and Rose-slugs, the Vine-slug and the Raspberry slug. The flies are small, black, with short and stout nine-jointed antennæ, and broad thin wings. "The larvæ are twenty and twenty-two-footed, presenting great differences in appearance and habit, being slimy, hairy or woolly, feeding in companies or alone, eating the whole leaf as they go, or, removing only the cuticle of the leaf, and forming sometimes one and sometimes two broods in a year. *Selandria vitis*, the Vine-slug, is twenty-footed; it has a smooth skin, and the body is somewhat thickened in the middle but slender towards the tail. "While growing, the color is green above, with black dots across each ring, and yellow beneath, with head and tail black. They live upon the vine and are very destructive, feeding early in August in companies, on the lower side of the leaf, and eating it all as they go from the edge inwards. There are two broods in a season. The fly is shining black, with red shoulders, and the front wings are clouded." (Norton.)

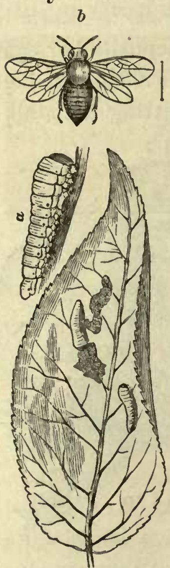


Fig. 148.

S. rubi Harris feeds on the raspberry, appearing in May. The larva is green, not slimy, and feeds in the night, or early in the morning. *S. tiliæ* feeds on the linden. The Pear-slug, *S. cerasi* Peck (Fig. 148, larvæ feeding on a leaf of the pear, and showing the surface eaten off in patches; *a*, enlarged; *b*, fly), is twenty-footed; it narrows rapidly behind the swollen thorax, and is covered with a sticky olive-colored slime. It feeds on the upper side of the leaves of both the wild and cultivated cherry and pear trees, and has been found on the plum and

mountain-ash. It appears in June and September. The fly is shiny black, with the tips of the four anterior femora, and the tibiæ and tarsi, dull white. An egg-parasite, belonging to the genus Encyrtus, renders, according to Peck, a great number of its eggs abortive.

The Rose-slug, *Selandria rosæ* Harris, is longer than the Pear-slug, the body being scarcely thickened anteriorly, and not covered with slime. It is pale-green and yellowish beneath. It appears in July and August, and does great injury in disfiguring and killing the leaves of the rose, which remain dried and withered on the bush. When full-fed, the larva, like the Pear-slug, makes a cocoon beneath the surface of the ground. The flies are seen in abundance about the rose-bushes as soon as the leaves are expanded, when they may be caught with nets, or the hand on cloudy days. Hand-picking, and the application of a very weak solution of carbolic acid, coal oil, whale oil soap, or quassia, are useful in killing the larvæ.


Fig. 149.

On the 25th of July a young friend brought me a large number of some remarkable larvæ (Fig. 149, natural size) of a saw-fly, which I surmised might belong to this genus. It presented the appearance of an animated, white, cottony mass, about an inch long and two-thirds as high. The head of the larva is rounded, pale whitish, and covered with a snow-white powdery secretion, with prominent black eyes. The body (Fig. 150, naked larva) is cylindrical, with eight pairs of abdominal legs, the segments transversely wrinkled, pale pea-green, with a powdery secretion low down on the sides, but above and on the back, arise long, flattened masses of flocculent matter (exactly resembling that produced by the woolly plant-lice and other Homopterous Hemiptera) forming an irregular dense cottony mass, reaching to a height equal to two-thirds the length of the worm, and concealing the head and tail. On the 27th and 28th of July the larvæ moulted, leaving the cast skins on the leaf. They were then naked, a little thicker than before, of a pale-green color,

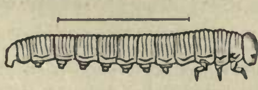


Fig. 150.

and were curled on the leaf. They eat out the edge of the leaf of the butternut tree. Sometime during August, two cocoons were spun between the leaves, but I did not succeed in raising the saw-fly. On describing the larva, in a letter to Mr. E. Norton, he kindly sent me alcoholic specimens of larvæ (without the woolly substance, which dissolves and disappears in alcohol) found feeding on the hickory, which are apparently, from the comparison of alcoholic specimens, identical with the Butternut Selandria. The adult fly (Fig. 151, ♂, *a*, cocoon), he has named *S. caryæ*, of which he has kindly furnished me with the subjoined description.*

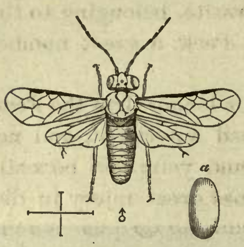


Fig. 151.

Allantus is closely related to Selandria, both in its structure and its habits, but differs in having the antennæ short and somewhat clavate. *A. basilaris* Say is a common species.

Fig. 152.

The Pine saw-fly, *Lophyrus*, may be known by the feathered antennæ of the male. *L. abietis* Harris (Fig. 152, female) infests the fir and pitch-pine. The male is black above and brown beneath, while the female is yellowish brown above,

* *Selandria caryæ* Norton, nov. sp. (Belonging to tribe 2. Under wings with one middle cell. Div. A. Antennæ filiform, short).

Female. Color shining black. The pro- and mesothorax and scutellum rufous. the apex of the latter black; the nasus and legs white, with their tarsi blackish; the base of coxæ and a line down the upper side of the legs black. Antennæ short, the second joint as long as the first; the four final joints together, not longer than the two preceding. Nasus slightly incurved. Claws of tarsi apparently bifid, Wings subviolaceous. Lanceolate cell petiolate, the first submedial cell above it, with a distinct cross vein. Under wings with one submarginal middle cell (all other species have this cell discoidal), the marginal cell with a cross nervure, and all the outer cells closed by an outer nervure, which does not touch the margin. The submedial cell extended nearly to margin. Length, .25 of an inch. Expanse of wings .40 of an inch.

"The male resembles the female, but the under wings are without middle cells. The larvæ feed upon the leaves of the hickory (Juglans squamosa.) They are found upon the lower side of the leaf, sometimes fifteen or twenty upon one leaf, which they eat from the outer extremity inward, often leaving nothing but the strong midribs. They cover themselves wholly with white flocculent tufts which are rubbed off on being touched, leaving a green twenty-two legged worm, about .75

with a short black stripe on each side of the thorax. The larvæ are about half an inch long, of a pale dirty green, yellowish beneath, striped with green, and when full-fed yellowish all over. They are social, and may often be found in considerable numbers on a single needle of the pitch-pine. The larvæ spin tough cocoons among the leaves, and the flies appear during August, but probably in greater numbers in the spring.

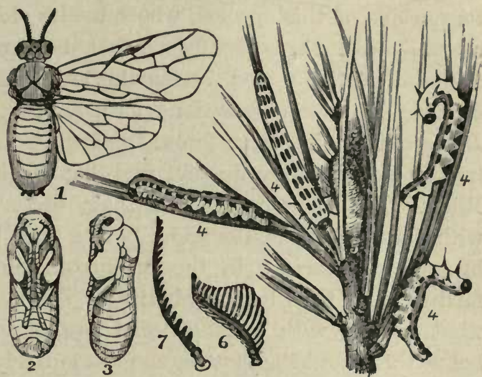


Fig. 153.

These slugs can be best destroyed by showering them with a solution of carbolic acid, petroleum, whale oil soap, or tobacco water. Mr. Fish has sent me the larvæ of a saw-fly, allied to L. abietis, which, in Eastham, Mass., ravaged the young pitch-pines planted in the sandy soil of that region.* The eggs are laid singly in the side of a needle of the pine; though sometimes an egg is inserted on each side of the leaf.

Mr. Riley has described the habits of the White-pine saw-fly,

of an inch in length when fully grown; darkest above, and with indistinct blackish spots upon the sides. The head is white with a small black dot upon each side.

"Specimens were taken upon the leaves July 4th. Went into the ground about the 20th of July. The cocoon is formed near the surface of the ground of a little earth or sand drawn together. Four specimens came forth about August 22d, all seeming very small for so large larvæ."

*On sending specimens of the male and female to Mr. Norton he writes that this is an undescribed species, of which he has prepared the following description:

"*Lophyrus pinus-rigida* Norton. New Species. Female. Length, 0.30; expanse of wings, 0.65 of an inch; antennæ seventeen-jointed, short, brown; color, luteous brown, with a black line joining the ocelli, a black stripe down each of the three lobes of the thorax above, and the sutures behind; body paler beneath; the trochanters and base of the tibiæ waxen; claws with an inner tooth near the middle; wings very slightly clouded; cross nervure of the lanceolate cell straight. Male. Length, 0.25; expanse of wings, 0.55 of an inch; antennæ fifteen-jointed, black, quite short, with twelve branches on each side, those at the base nearly as long as the sixth and seventh; apical joint simple, enlarged at base; color of insect black, with the abdomen at apex and beneath yellow-brown; legs the same color at base; below the knees whitish.

L. Abbotii Leach. The flies appear early in June, and there is but a single brood of larvæ, which remain on the trees, in Illinois, until November, and hibernate before changing to pupæ. The female is honey-yellow, with pale rufous legs, and the male is jet black. Fig. 153 represents, after Riley, the transformations of this species, whose habits closely resemble those of L. abietis. 1, is the fly somewhat magnified; 6, magnified antenna of the male; 7, female antenna; 2 and 3, pupæ; 4, larvæ in different positions, natural size; 5, cocoon. The *L. Lecontei* Fitch has been found feeding on the Scotch and Austrian pines in New Jersey, and has been described by Mr. Riley. The larva is an inch long, dirty or yellowish white, with dorsal black marks wider before than behind, and usually broken transversely in the full-grown individuals; they are farther apart than in L. Abbotii. "The lateral spots are somewhat square, with an additional row of smaller black marks below them, and the last segment is entirely black above. The antennæ of the male fly are twenty-one-jointed, and have on one side seventeen large, and on the other seventeen small branches, there being eighteen on one side and fifteen on the other in L. Abbotii. The female may at once be distinguished from L. Abbotii by her abdomen being jet-black above, with a small brown patch at the end, and a transverse line of the same color just below the thorax."

There are several allied genera, such as *Cladius* (*C. isomera* Harris), *Lyda* (*L. scripta* Say), and *Xyela* (*X. infuscata* Harris), which belong here. The last genus, *Cephus*, which by some

"The females of Lophyrus are all much alike and I have found the number and forms of the joints of the antennæ, so far, the only reliable guide. The male looks precisely like that of *L. abietis*, but the form of the antennæ differs in being much shorter. The female looks much like *L. abdominalis* Say, taken on the pine near New York. The following list will show how the species may be distinguished by counting the number of joints."

L. Fabricii Leach,	male,	not described,	female,	16 joints.	
L. compar Leach,	"	" "	"	16 "	
L. pinus-rigida Norton,	"	15 joints	"	17 "	Pine.
L. Abbotii Leach,	"	not described	"	17 "	"
L. abietis Harris,	"	21 joints,	"	18 "	
L. abdominalis Say,	"	not described,	"	18 "	Pine.
L. pinetum Norton,	"	19 joints,	"	18 "	"
L. Americanus Leach,	"	not described,	"	19 "	
L. insularis Cresson,	"	17 joints,	"	20 "	Pine.
L. Lecontei Fitch,	"	17 "	"	21 "	

authors is placed in the next family, is retained by Norton in the present group. The larva is, in Europe, injurious to rye and wheat, boring in the stems of the plant. *Cephus abbreviatus* Say is our more typical form, though rarely met with. *C. trimaculatus* Say is found in New York early in June, according to Dr. Fitch.

UROCERIDÆ Leach. The family of "Horntails" are so-called from the long prominent horn on the abdomen of the males, while the ovipositor or "saw," resembling that of the true saw-flies, is attached to the middle of the abdomen, and extends far beyond its tip. They are of large size, with a long cylindrical body and a large head, square next the thorax, but much rounded in front. The antennæ are long and filiform. The larvæ are "cylindrical fleshy grubs, of a whitish color, with a small rounded horny head, and a pointed horny tail. They have six very small legs under the fore-part of the body, and are provided with strong and powerful jaws, wherewith they bore long holes in the trunks of the trees they inhabit. Like other borers these grubs are wood-eaters, and often do great damage to pines and firs, wherein they are most commonly found." Harris farther states that, when about to transform, the larvæ make thin cocoons of silk in their burrows, interwoven with little chips made by the larva. "After the chrysalis skin is cast off, the winged insect breaks through its cocoon, creeps to the mouth of its burrow, and gnaws through the covering of bark over it, so as to come out of the tree into the open air."

Xiphidria is so-called from the sword-like ovipositor, which is much shorter than in the succeeding genera. The body is a little flattened, somewhat turned up behind, and the tip of the abdomen ends in an obtuse point, while the antennæ are short, curved and tapering at the end. *Xiphidria albicornis* Harris is black with yellowish legs and white antennæ, with the two lowest joints black. It is nearly three-fourths of an inch long.

The typical genus of the family is *Urocerus*, which has a large body, with a large ovipositor and long, sixteen to twenty-four-jointed antennæ, while the body of the male ends in a stout acute horn. *U. albicornis* Fabricius has white antennæ, and the female is of a deep blue-black color, while the male is black. It is found on pine trees in July. It is an inch in length.

The genus *Tremex* is known by the wings having two marginal and three submarginal cells. *Tremex Columba* Linn. infests the elm, pear and button-wood. The female is an inch and a half long, rust-red, varied with black, while the abdomen is black with seven ochre-yellow bands on the upper side, all but the two basal ones being interrupted in the middle. They fly during the last of summer.

"Dr. Harris thus describes the habits of this interesting insect. The female, when about to lay her eggs, draws her borer out of its sheath, till it stands perpendicularly under the middle of her body, when she plunges it, by repeated wiggling motions, through the bark into the wood. When the hole is made deep enough, she then drops an egg therein, conducting it to the place by means of the two furrowed pieces of the sheath. The borer often pierces the bark and wood to the depth of half an inch or more, and is sometimes driven in so tightly that the insect cannot draw it out again, but remains fastened to the tree till she dies. The eggs are oblong oval, pointed at each end, and rather less than one-twentieth of an inch in length.

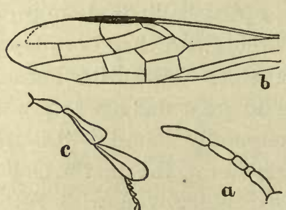


Fig. 154.

"The larva, or grub, is yellowish white, of a cylindrical shape, rounded behind, with a conical, horny point on the upper part of the hinder extremity, and it grows to the length of about an inch and a half. It is often destroyed by the maggots of two kinds of Ichneumon-flies (Rhyssa atrata and lunator of Fabricius). These flies may frequently be seen thrusting their slender borers, measuring from three to four inches in length, into the trunks of trees inhabited by the grubs of the Tremex, and by other wood-eating insects; and like the female of the Tremex they sometimes become fastened to the trees, and die without being able to draw their borers out again."

We have noticed the trunk of an elm, at Saratoga Springs, perforated by great numbers of holes, apparently made by these insects. *T. latitarsus* Cresson (Fig. 154; *a*, antenna; *b*, wing; *c*, hind leg) is remarkable for the expansions on the hind legs. It lives in Cuba.

LEPIDOPTERA.

Butterflies and Moths are readily recognized by their cylindrical, compact bodies; their small head, with its large clypeus; by the maxillæ being prolonged into a tubular

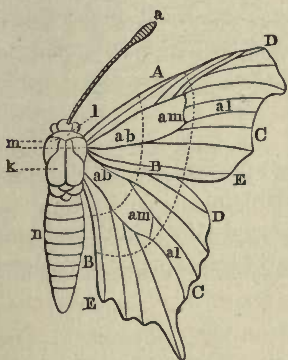


Fig. 155.*

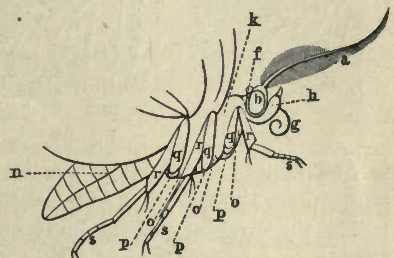


Fig. 156.

"tongue;" the obsolete mandibles; and the broad, regularly veined wings, which are covered with minute scales.

Their transformations are complete; the active larvæ assuming a cylindrical, worm-like form, being rarely footless, and

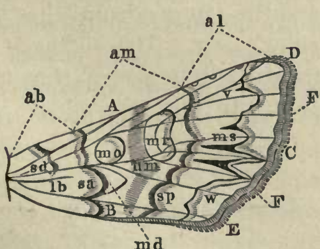


Fig. 157.

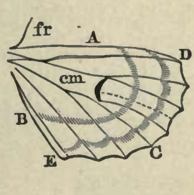


Fig. 158.

having from one to five pairs of fleshy abdominal legs, besides the three pairs of corneous jointed thoracic limbs. A large proportion (butterflies excepted) spin silken cocoons before

*For explanation of cuts, 155 to 171, see pages 233 and 234.

changing to pupæ (chrysalids, nymphs). In the pupa state the limbs and appendages of the head are soldered together, and the head and thorax tend to form one region, upon which the third region, or abdomen, is more or less movable. Three

Fig. 159.

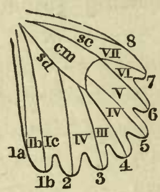


Fig. 160.

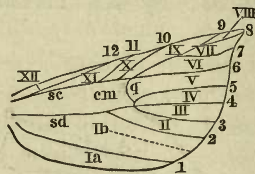


Fig. 161.

or four genera of the lower families are partially aquatic, while, as a whole, the suborder is purely terrestrial.

The three regions of the body are very distinct, but the head, though free, is smaller and with its parts less equally developed

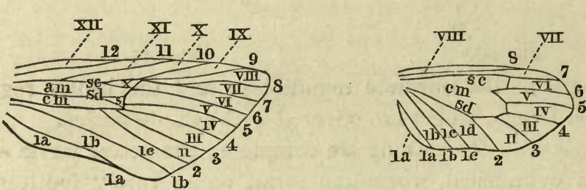


Fig. 162.

than in the Hymenoptera, and the "propodeum" has now become plainly the first abdominal ring. The abdomen is also longer, with the genital armor partially exserted, thus showing a tendency to decephalization. In fine, the whole body is

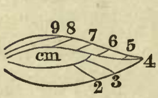


Fig. 163.

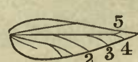


Fig. 164.

loosened and less compact than in the Hymenoptera. Their broad wings; obsolete mouth-parts, with the abnormally developed maxillæ; and active larvæ, with their worm-like shape,

are also characters which show that they are more degraded than the Hymenoptera. There is also a greater disproportion in the relative size of the three thoracic rings. In the abdominal rings the pleurites are much larger than in Hymenoptera, where they are partially obsolete. They scarcely use the legs, the fore pair (so remarkably differentiated in the higher Hymenoptera) being partially obsolete in some butterflies (Vanessa, etc.). They are essentially fliers, not having the great variety in the mode of locomotion observable in the Hymenoptera. No parasites are known to occur in this suborder. They are only social while in the larval state, and then merely because their eggs, in such instances, are laid in bunches, and on distinct food-plants to which the larvæ are confined. The adults rarely take an active part in the economy of nature, and have but little opportunity for the manifestation of instinct and reason, though the larvæ in seeking for suitable places in which to undergo their transformations often exhibit wonderful instinct.

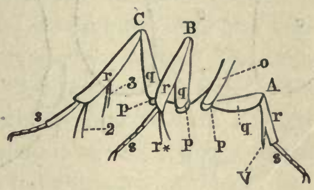


Fig. 165.

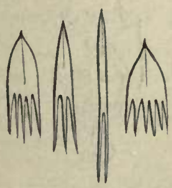


Fig. 166.

The readiest method of determining the natural position of groups is by a comparison of their degradational forms. Thus we find that in the degraded Hymenoptera the tripartite form of the body is preserved; while, on the contrary, in the wingless Lepidoptera (such as the female of Orgyia and Anisopteryx) the body is either oval, the head being less free and smaller than in the winged form, and the thorax and abdomen continuous, their respective rings being of much the same size and shape, while the legs are feeble: or, as in the female of Œketicus, the body is elongated, and worm-like. The wingless moths, then, are much lower than the worker ants, the female Scolia,

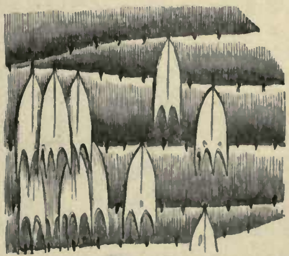


Fig. 167.

etc., giving us an unfailing test of the difference in rank of the two suborders. In their habits and transformations, and in their external anatomy, the Lepidoptera vary less than other insects.

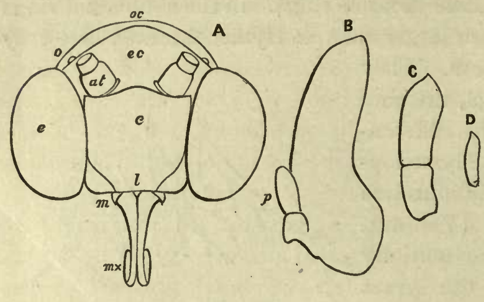


Fig. 168.

The Lepidoptera, while in the perfect state, can be scarcely said to walk much, compared with beetles and other walking insects, the legs being only used to support them while at rest, and not for locomotion. They move almost entirely by their broad wings, which with them are more highly specialized than in other insects. Their fore wings are usually triangular in form, while their hind wings are somewhat square or rounded. The anterior wings are the most typical in form and venation.

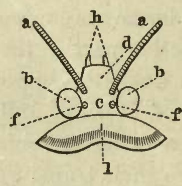


Fig. 169.

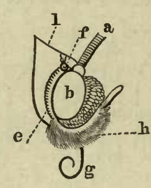


Fig. 170.

The surface, from the costa to the inner edge, may be

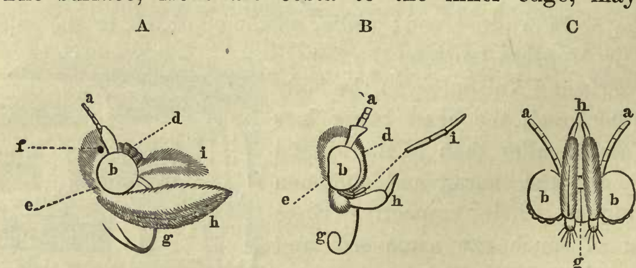


Fig. 171.

divided into three areas, — the costal, median, and internal. There are five principal veins: the costal and subcostal are

grouped together, and form the *costa* or front edge of the wing; the median occupies the middle of the wing; and the submedian and internal, the hinder, or internal, area of the wing. The costal vein is usually simple, and joins the costa near its outer third. The subcostal, near the middle of the wing, is usually subdivided into five branches, which are called *venules*, while the median is usually subdivided into one venule less, and the submedian and internal are simple. The last, or fifth, subcostal venule, and the first median venule, generally each throw out a small venule, which meet to form the discal venule, thus enclosing a large central area called the discal area, or cell. There are rarely any cross venules present. Sometimes, as in Hepialus, there is a transverse costal venule, and an interno-submedian venule. They are usually found only in degraded Lepidoptera, and recall the net-veined style of venation of the Neuroptera.

The legs are slender, cylindrical, and weak. The coxæ are closely united with the thorax, the trochanters are spherical,

FIGS. 155, 156, give a general view of the body of a butterfly denuded of scales. FIG. 155. *a*, antenna; 1, prothorax; *m*, patagia, or shoulder-tippets; *k*, mesoscutum; *n*, abdomen; A, costal edge of fore-wing; D, apex; C, outer edge excavated; E, outer angle; B, inner edge; *ab*, discal cell; *am*, discal venules, throwing off the independent vein, *al*. The dotted lines indicate the inner, middle and outer third of the wing. FIG. 157 illustrates the mode of ornamentation of the wings of moths; *ab*, *am* and *al*, the inner, the middle, and outer third of the wings. The capitals are the same as in FIG. 155; *sd*, the basal line; *sa*, the inner line; *sp*, the outer, and *ms*, the marginal line variously waved, scalloped and angulated. In most of the Noctuidæ are the dentiform spot, 1 *b*; *mo*, the orbicular, and *mr*, the reniform spots; between the two latter often runs the transverse shade, *um*. In FIG. 158, hind wing, *fr* indicates the "bristle" which fits into the "hook" on the fore-wing, uniting the two wings during flight; *cm*, situated in the discal cell, indicates the "lunule," and beyond are the outer and marginal dusky bands. FIG. 159, 1 *a*, internal vein; 1 *b*, submedian vein; 2, 3, 4, 5, the four branches (venules) of the median vein (in FIG. 160, 5 becomes the independent venule); 6 to 12, branches of the subcostal (in FIG. 161, xii, is the costo-subcostal recurrent venule). In FIG. 162, wings of the Hepialus, the venation is more irregular, and in the fore-wing the discal cell is divided into an anterior and posterior discal cellule, by the disco-longitudinal vein; *sd*, *x*, and *s*, accessory cells. In the Tineids the venation is very simple. In FIG. 163, the submedian and internal veins have disappeared; 9 is the costal vein; 2, 3, the two branches of the median vein; 4 to 8, branches of the subcostal vein. In FIG. 164, the internal vein is shortened, and the submedian forked, while the median and subcostal are merged together.—*From Heinemann, in Morris's Synopsis, Smithsonian Miscellaneous Collections.* Compare also FIG. 29 on page 23.

FIGS. 156 and 165. *a*, antenna, on one side wholly, and on the other partially, pectinate; *b*, eye; *f*. ocellus; *h*, labial palpus; *g*, maxillæ or "tongue;" *o*, coxa; *p*, trochanter; *q*, femur; *r*, tibia; V, single anterior spur; *r**, two middle tibial spurs; 2, 3, two pairs of posterior tibial spurs; *s*, tarsus.

and the femora, tibiæ and tarsi, slender and very equal in length. There are usually two tibial spurs. The tarsus is five-jointed, the terminal joint ending in two slender claws.

The scales covering the body of Lepidoptera are simply modified hairs. In studying the wing of the Cecropia moth, we find the hairs of the body and base of the wing gradually passing into the forms represented in Fig. 166. They are attached to the wings and laid partially over one another like the tiles on a roof (Fig. 167). They are inserted in somewhat regular lines, though, as seen in the figure, these lines are often irregular, as shown by the line of scars where the scales have been removed. The scales are beautifully ornamented with microscopic lines. We find, on removing the scales, that the head consists of three well-marked pieces,* *i. e.* the occiput or basal piece which lies behind the ocelli; the epicranium, lying behind the insertion of the antennæ, and carrying the eyes and ocelli, and the clypeus, which constitutes the front of the head. The latter piece is larger than in all other insects, its size being distinctive of the Lepidoptera. There is a general form of this piece for each family, and it affords excellent characters in the different genera, especially among the butterflies (as Mr. L. Trouvelot has shown us in a series of drawings made by him), and the *Zygænidæ* and *Bombycidæ*. It is largest, and most perfectly shield-shaped, in the Attaci. In the *Phalænidæ*, it is smaller, and square; and in the *Tineidæ* it is smaller still, while the occiput and epicranium are larger.

The labrum is remarkably small and often concealed by the overhanging clypeus. The labium is small, short, triangular, and the mentum is nearly obsolete. The lingua is obsolete, its place being supplied by the tongue-like maxillæ. The labial palpi are feebly developed, sometimes rudimentary, and consist

* FIG. 168. A, head of Ctenucha Virginica denuded; *oc*, occiput; *ec*, epicranium, with the two ocelli, *o*, and the base of the antennæ, *at*; *e*, eye; *c*, clypeus; *l*, labrum; *m*, mandible; *mx*, tongue, or maxillæ, with the end split apart; B, rudimentary maxilla of Actias Luna, with its single-jointed rudimentary palpus, showing the mode of attachment to the base of the maxilla; C, two-jointed, rudimentary labial palpus of A. Luna; D, the same, single jointed, of Platysamia Cecropia.

FIGS. 169, 170. Head of a moth in relation to the prothorax (1). FIG. 171, A, B, side view and (C) front view of the head of a moth; *a*, antenna; *b*, eye; *d*, the "front;" *e*, orbit of the eye; *f*, ocellus; *g*, maxilla situated between *h*, the three-jointed labial palpi; *i*, the maxillary palpus, sometimes very large and three-jointed.

of from one to three joints, the terminal one being small and pointed. They are recurved in front of the head, on each side of the spiral tongue, and are covered with hairs; their function, as *touchers* or feelers, seeming to be lost. The mandibles are rudimentary, consisting of a pair of horny tubercles, partly concealed by the front edge of the clypeus. The maxillæ, on the other hand, are remarkably developed. In

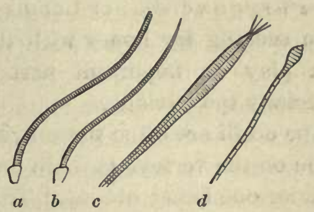


Fig. 172.

their rudimentary state, as in Attacus, they form a pair of grooved blades, the hollowed sides being opposed and held

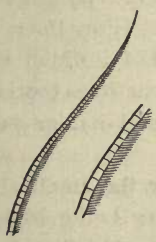


Fig. 173.


Fig. 174.

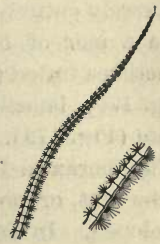


Fig. 175.

together by a row of minute teeth, thus forming a canal. The insect sucks through this long tube the sweets of flowers.

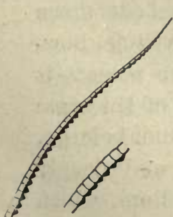


Fig. 176.


Fig. 177.

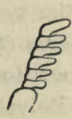


Fig. 178.

Fig. 179.

The "tongue" is often nearly as long as the body of the insect itself, and when at rest, is rolled up and held between the palpi. At its base are the minute rudimental maxillary palpi,

which are generally concealed, but are apparent in the smaller and lower moths, Crambus and the Tineids. They are usually from two to three-jointed, and even five to six-jointed, as in Tinea granella, and longer than the maxillæ, thus resembling the *Phryganeidæ*, or Caddis flies.

In seeking for honey with their long maxillæ, the Lepidoptera play an important part in the fertilization of plants, especially the Orchids.

The ocelli are often present, though they do not form a triangle on the vertex, as there are only two, the third and most anterior one being absent. The eyes are large and globose, and vary in their distance apart in different families.

The antennæ vary greatly; they are either filiform (Fig. 172, *a*), or setiform (Fig. 172, *b*), or fusiform, as in the Sphinges (Fig. 172, *c*), or club-shaped, as in Papilio (Fig. 172, *d*). They are rarely entirely naked, but are finely ciliated (Fig. 173), or have a pair of bristles on each joint (Fig. 174), which are sometimes tufted (Fig. 175). The joints are sometimes toothed (Fig. 176), lamellate (Fig. 177), serrate (Fig. 178), or pectinate (Fig. 179).

The thorax in Lepidoptera is remarkable for the small size of the first, or prothoracic ring, the mesothorax being highly developed. In Telea (Figs. 11 and 12, on page 11) the characteristic form is well shown. The tergal arch of the prothorax is almost obsolete, the scutum alone being represented by a corneous piece, while the pleural parts are more developed as supports for the forelegs. In the mesothorax the præscutum is present, but is usually vertical, being bent down and concealed between the two rings, becoming visible, however, from above in Hepialus (Sthenopis), in which respect it strikingly resembles the position and development of the same piece in the neuropterous Polystœchotes. The scutum is large, with convex sides, broadest behind the middle, and deeply notched for the reception of the triangular scutellum, which is about one-fourth the size of the scutum. The postscutellum is transverse, and situated out of sight, unless the two hinder thoracic rings are separated, under the scutellum. The episterna and trochantines are large, and the whole mesothoracic flanks nearly twice as wide as those of the metathorax. The

metathorax is much compressed antero-posteriorly. The scutum is thrown aside as it were by the scutellum into two lateral, nearly square halves, the remaining tergal pieces being usually obsolete and membranous, but in Sthenopis the præscutum and scutellum (Fig. 13, page 12) are large, and meet in the middle of the segment, much as in the neuropterous *Sialidæ* and *Hemerobiidæ*.

The abdomen is oval in Papilio, becoming long and linear in the Tineids. In the *Zygænidæ*, especially, the basal ring is membranous and is partly adherent to the thorax, and somewhat inflated on each side. The number of abdominal segments varies, being either eight or nine; the variation occurring, as stated by Lacaze-Duthiers, in closely allied genera; thus the genital and anal openings are placed more usually behind the eighth, but sometimes behind the ninth segment.

The genital armor is very simple, consisting of two valve-like pieces. The parts beyond (anal stylets, etc.) are aborted, so that the anus and external opening of the oviduct are brought closely together. In the male the parts are more complex, the anal forceps often, as in the Callosamia Promethea, forming long curved hooks for clasping the abdomen of the female.

The nervous system of Lepidoptera, and its changes during the transformations of the larva, have been studied most thoroughly by Herold (in Pieris) and Newport (in Sphinx ligustri and Vanessa urticæ). In the imago the ventral cord consists of seven ganglia, while in the larva there are eleven. This decrease in their number is due to the fusion, during the pupa state, of the first, second, third and fourth ganglia of the larva, exclusive of those situated in the front part of the head; these form the two thoracic ganglia which distribute nerves to the legs and the muscles of the wings. Meanwhile the fifth and sixth ganglia of the larva have either disappeared entirely, or been united with the others.

The digestive system (see Fig. 44, on page 35) of butterflies and moths is modified to suit their peculiar habits. They draw in the sweets of plants through the "tongue" by a sucking stomach which opens into the hinder end of the œsophagus. "The ileum is long, small, and nearly always forms several

convolutions. The colon is constantly of a large size, and is often dilated into a cæcum at its anterior portion." (Siebold.) The salivary glands are composed of two simple tubes, which are very large in the larval state, extending into the abdomen.

The respiratory system is normal and well developed. In the larva the stigmata are wanting on the second and third thoracic and last abdominal segment. In those species of *Sphingidæ*, *Bombycidæ* and *Noctuidæ*, which have a long-sustained flight there are numerous vesicular dilatations of the tracheæ.

The urinary tubes are six in number; they are long, free, and open into the stomach by two excretory ducts.

The silk-glands consist of two long, flexuous, thick-walled sacs, situated on the sides of the body, and opening by a common orifice on the under lip (labium) usually at the extremity of a short tubular protuberance (Siebold). They are most developed when the larva approaches the pupa state. We once found a larva of Clisiocampa Americana that had just spun its cocoon, and to ascertain whether the silk had been exhausted, we removed the worm from its cocoon, when it spun another, but thinner one; and upon removing it a second time it spun a third very thin cocoon, before the supply of silk was entirely exhausted.

The ovary consists of four very long, spiral, multilocular tubes. The *receptaculum seminis* is pyriform, and often has a long, spiral *ductus seminalis*. At its base is situated a large, double sebaceous gland; and there are two small ramose glands, perhaps odoriferous, situated at the orifice of the vagina. The copulatory pouch is a remarkably large, pyriform reservoir, having for the reception of the male intromittent organ a canal, which opens by a special orifice, situated below and behind the external opening of the oviduct. (Siebold.)

The testes form two round or oval follicles, and the two short deferent canals unite with two simple and very flexuous accessory glands, to form the long *ductus ejaculatorius*.

Several interesting cases of hermaphroditism in butterflies and moths have been published by European entomologists. Mr. Edwards has noticed two remarkable instances in the Proceedings of the Philadelphia Entomological Society (vol. iv,

p. 380), the latter of which we have also seen. "A specimen of Papilio Asterias is in my collection, and was captured by Mr. J. Meyer of Brooklyn, L. I., two or three years since. It is a fine instance of a perfect hermaphrodite. The right wings are both male, the left wings both female, distinctly marked upon both surfaces with no suffusion of color. The size is that of the largest specimens of Asterias. The Saturnia Promethea is in the collection of Mrs. Bridgham of New York, and is a curious instance of an imperfect hermaphrodite. The left antenna and left primary are male; the right antenna and left secondary are female; the right primary is also female, but the right secondary is something between the two, neither male nor female. The color of the upper surface is nearly the same as the under surface of the male. On the under side the color and markings of the left primary are male, but the other three wings are female. The color and markings of the male Promethea are quite different from those of the female, and on this hermaphrodite the confusion of the sexes is conspicuous. It is a bred specimen. The body had been viscerated, so that it is impossible to determine its sex."

The larva of Ctenucha, which resembles that of Arctia, constructs its cocoon out of the hairs of its body, without spinning any silken threads, so far as we could ascertain by microscopical examination. The hairs of this, as of probably most hairy caterpillars, but more especially the Bombycid larvæ, are thickly armed with minute spinules, so that by being simply placed next to each other, they readily adhere together. The cocoon is finished in about twelve hours. We once noticed a Ctenucha larva just beginning its cocoon. Early in the morning it described an ellipse upon the side of the glass jar in which it was confined, out of hairs plucked from just behind its head. From this elliptical line as a base, it had by eight o'clock built up, rather unequally, the walls of its cocoon, in some places a third of the distance up, by simply piling upon each other the spinulated hairs, which adhered firmly together. At four o'clock in the afternoon, the arch was completed, and the larva walled in by a light partition, and soon afterwards the thin floor was made. No silk is spun throughout the whole operation, while in the cocoon of Pyrrharctia isabella there is a slight frame-work of silk upon which the hairs are placed.

Trouvelot states that the Polyphemus larva constructs its cocoon by drawing the leaves together as a support for the threads, forming the foundation of the cocoon. "This seems to be the most difficult feat for the worm to accomplish, as after this the work is simply mechanical, the cocoon being made of regular layers of silk united by a gummy substance. The silk is distributed in zig-zag lines of about one-eight of an inch long. When the cocoon is made, the worm will have moved his head to and fro, in order to distribute the silk, about two hundred and fifty-four thousand times. After about half a day's work, the cocoon is so far completed that the worm can hardly be distinguished through the fine texture of the wall; then a gummy, resinous substance, sometimes of a light brown color, is spread over all the inside of the cocoon. The larva continues to work for four or five days, hardly taking a few minutes of rest, and finally another coating is spun in the interior, when the cocoon is all finished and completely air-tight. The fibre diminishes in thickness as the completion of the cocoon advances, so that the last internal coating is not half so thick and so strong as the outside ones."

In those moths which spin a thick cocoon, the pupa, a few days previous to its exit, secretes an acid fluid from two glands opening into the mouth. This fluid, according to Mr. L. Trouvelot (American Naturalist, vol. i, p. 33), in his account of the Polyphemus silk-worm, dissolves the hard gummy substance uniting the silken threads, until after the expiration of half an hour, the moth is able to push the fibres aside, and work its way out, without breaking a thread.

Trouvelot says that the larvæ of the Polyphemus moth (and this remark will probably apply to all other Lepidopterous larvæ) seem entirely unable to discern objects with their simple eyes, but can distinguish light from darkness.

In their adult state butterflies and moths take but little food, consisting of honey, though Papilio Turnus, according to a Canadian observer, is attracted to heaps of decaying fish.

Caterpillars grow very rapidly, and consume a great quantity of food. Mr. Trouvelot gives us the following account of the gastronomical powers of the Polyphemus caterpillar. "It is astonishing how rapidly the larva grows, and one who has no experience in the matter could hardly believe what an amount

of food is devoured by these little creatures. One experiment which I made can give some idea of it: when the young silk worm hatches out, it weighs one-twentieth of a grain; when

10	days old it weighs	1-2 a grain,	or	10	times its original weight.
20	" " " "	3 grains	"	60	" " " "
30	" " " "	31 "	"	620	" " " "
40	" " " "	90 "	"	1800	" " " "
56	" " " "	207 "	"	4140	" " " "

When a worm is thirty days old it will have consumed about ninety grains of food; but when fifty-six days old it is fully grown and has consumed not less than one hundred and twenty oak leaves weighing three-fourths of a pound; besides this it has drank not less than one-half an ounce of water. So the food taken by a single silk-worm in fifty-six days equals in weight eighty-six thousand times the primitive weight of the worm. Of this, about one-fourth of a pound becomes excrementitious matter; two hundred and seven grains are assimilated and over five ounces have evaporated. What a destruction of leaves this single species of insect could make if only a one hundredth part of the eggs laid came to maturity! A few years would be sufficient for the propagation of a number large enough to devour all the leaves of our forests." The Lepidoptera are almost without exception injurious to vegetation and are among the chief enemies of the agriculturist.

They are rarely found fossil owing to the delicacy of their bodies. Remains, doubtfully referred to the Lepidoptera, have been found in the Jura formation. A Sphinx-like moth has been discovered in the Tertiary formation of Europe, and a few minute forms have occurred in Amber.

Butterflies are easily distinguished from the other groups by their knobbed antennæ. In the Sphinges and their allies the feelers are thickened in the middle: in the Moths they are filiform and often pectinated like feathers. Lepidoptera have also been divided into three large groups, called Diurnal, Crepuscular and Nocturnal, since butterflies fly in the sunshine alone, most Sphinges in the twilight (some of them, however, fly in the hottest sunshine), while the moths are generally night-fliers, though many of them fly in the day time, thus showing that the distinctions are somewhat artificial.

The larger Lepidoptera (butterflies and the larger moths)

have been called *Macrolepidoptera*, while the smaller ones, including the smaller *Pyralidæ*, the *Tortricidæ*, and the *Tineidæ*, are called *Microlepidoptera.*

In studying these insects the best generic characters will be found in the antennæ, the shape of the head-parts, the venation and proportions of the wings: very slight changes in these parts separating genera and species. Size and coloration, which are usually very constant, afford good specific characters.

A good method of preserving larvæ dry, adopted at Dresden, is to squeeze out the intestines through a hole made near the anal extremity of the larva, then to insert a fine straw, after which it may be placed in a glass vase, itself placed in a tin vessel and held over a lamp; the larval skin is blown while suspended over the lamp, by which the skin dries faster. It may be done with a small tube or blow-pipe fixed at the end of a bladder, held under the arm or between the knees, so as to leave the hands at liberty; and the straw which is inserted into the body of the larva may be fastened by a cross-pin stuck through the skin, and thus retained in its proper position throughout the process of blowing. The small larvæ, such as those of the Tineæ, may be put alive into a hot bottle, baked until they swell to the proper extent and dry, when they can be pinned with all their contents inside. (Westwood, Proceedings of the Entomological Society of London, Sept. 7th, 1863.)

Dr. Knaggs has, in the Entomologist's Monthly Magazine, given some directions for managing caterpillars. Very young caterpillars, which will not eat the food provided, and become restless, should be reared in air-tight jam-pots, the tops of which are covered with green glass to darken the interior of the vessel. When small larvæ hide themselves by mining, entering buds and spinning together leaves, they should have as small a quantity of food as possible. In changing larvæ from one plant to a fresh one, a slight jar or puff of breath will dislodge them, and they can be transferred to the jam-pot, or the glass cylinder, covered at one end with muslin, can be turned muslin end downwards for them to crawl upon. The duplicate breeding cage, pot or tube, should be "sweetened" by free currents of fresh dry air and then stocked with fresh food.

Dr. Knaggs advises that "hiding places," or bits of chips,

etc., be provided for such Noctuid larvæ as naturally lie concealed, such as *Orthosia*, *Xanthia*, *Noctua*, etc., "while for *Agrotis* and a few others a considerable depth of fine earth or sand is necessary."

"Larvæ, which in nature hibernate, must either be stimulated by warmth and fresh food to feed up unnaturally fast, or else through the winter must be exposed to out-door temperature." For such larvæ as begin to eat before the trees are leaved out, the leaves of evergreens must be provided, pine leaves, chickweed, grasses and mosses. Hibernating, living larvæ, must during the winter be kept dry, otherwise the damp seems to hang about their fur, and causes them to be attacked by a white fungus; while smooth larvæ require the natural dampness of the soil. Mr. Gibson strongly recommends that during the winter all cages containing larvæ be placed in front of a window facing the east or north-east, so that the inmates may be kept as cool as possible.

When the moth is fairly out of the pupa, as remarked by Mr. Sanborn, their wings often fail to properly expand, on account of the want of moisture, "the insect being unable to expand its wings in a heated, dry room. He has avoided this difficulty by placing the insect just emerged, or about to come forth, beneath a bell-glass, within which he had placed moistened pieces of bibulous paper."

Mr. Trouvelot has noticed that the difference in size of the wings of moths or butterflies is due to the fact that some of the fluid thrown into the wings during their development escapes from a break in the surface of the wing, so that this wing is smaller than the other. He has, by pinching a wing while thus developing, caused the fluid to "flow from the puncture, and immediately the wing so wounded ceased to grow, while the three others continued their development to its full extent." "I have sometimes advanced the development of the wings of Telea Polyphemus. I selected for this purpose, pupæ very far advanced in their transformation, as is shown by the looseness of the pupal skin, and by the color of the wings of the moth, which can be seen through it. I took carefully the pupal skin from around the moth and suspended the insect in the position that Lepidoptera take when emerging from the

chrysalis. It is very rare that the wings of such an insect are developed, though I have obtained some perfect specimens in this way; and in one instance the development of the wings took place only three days after the pupal skin had been removed. Success is more certain if the insect is put under a glass jar with a moistened sponge, and something for the insect to hang from; the dampness of the air in the jar will prevent the soft wings from drying too fast, and when the time arrives for the insect to accomplish its transformation, the fluid will be active. Such an insect has much analogy with a vertebrate born prematurely; the insect, like the quadruped, remains almost motionless till the natural time for its birth arrives."

PAPILIONIDÆ Latreille. The Butterflies, or Diurnal Lepidoptera, are at once distinguished from the moths by their knobbed antennæ, though they are sometimes nearly filiform. The body is small, but there is a greater equality in the size of the three regions than in the moths, the abdomen being much shorter and smaller, as a general rule, than in the lower families. The ocelli are usually wanting; the spiral tongue or maxillæ, are long and well developed; and the wings are carried erect when in repose, and are not held together during flight by a bristle and socket as in the moths.

The larvæ vary greatly in shape and in their style of ornamentation, but they uniformly have, besides the thoracic legs, five pairs of abdominal legs. The pupa is called a "chrysalis" or "aurelian" from the bright golden hues which adorn those of many species. They disappear as the wet tissues beneath the pupa-skin harden just before the fly appears. The pupa is usually angulated on the sides of the thorax and along the upper side of the abdomen. A few species, such as those of Vanessa, hibernate, while several species, such as Vanessa Antiopa, are social as young larvæ. The most "perfect state of society is exhibited by a Mexican butterfly (Eucheira socialis Westwood), the caterpillars of which construct a very strong parchment-like bag, in which they not only reside, but undergo their change to the pupa state." Butterflies also occasionally swarm while in the perfect state, such as species of Colias, Cynthia and Danais, multitudes of which are sometimes seen passing over-

head in long columns. They are truly tropical insects, since Gerstaecker mentions that three times as many species (600) occur at a single point (Para, Brazil) as in all Germany, where scarcely 200 species live. There are about 5,000 species known; 900 inhabit North America and probably the number will be increased to a thousand, while Mr. Scudder enumerates ninety-five species which have already been found in New England.

The noble genus *Ornithoptera* has very long, slightly knobbed antennæ, and a well developed prothorax; while the fore-wings are very large, elongated, triangular, and the hind wings are relatively smaller and rounded. *O. Priamus* Linn. is found in the Moluccas. There are twenty species known. The larvæ differ from those of Papilio in having an external forked sheath for the "tentacles." The pupa is sustained by a silken thread on each side, attached to a small lateral tubercle.

Of the extensive genus *Papilio*, or "Swallow-tail," over 300 species are known. The larva is rather short and stout, with a v-shaped scent-organ, or "tentacles." The pupa is supported by a filament passed entirely around it. The common *P. Asterias* Drury appears in New England in June, when it lays its eggs on the leaves of parsley and other umbelliferous plants. From this brood a new set of butterflies appear in August. The larva is yellow, striped and spotted with black, and when irritated, pushes out, from a slit in the prothoracic ring, a v-shaped, yellow, fleshy, scent-organ, used as a means of defence. The chrysalis is free, attached by the tip of the abdomen and supported by a loose silken thread, which is passed over the back. It lives in this state from nine to fifteen days. It has two ear-like projections on each side of the head and a prominence on the back of the thorax.

Mr. W. Saunders has received from St. John's, Newfoundland, several specimens of a butterfly, one of which I have before me, and which seems to be a very remarkable variety of P. Asterias, rather than a distinct and undescribed species, as supposed by my friend to whose collection it belongs. He writes me, after giving a detailed description, presented below,*

* "*Papilio brevicauda* Saunders. Female. Expands three and one-fifth inches; head, palpi and antennæ black; thorax black, fringed with yellow hairs on each side, for about half its length; body above black, with a row of seven or eight yellow spots along each side which are largest about the middle of the row; under

that "this species resembles P. Asterias, but differs from it in many points. In P. Asterias the palpi are edged within with yellow; in P. brevicauda they are black. P. Asterias has two yellow spots above at the base of the antennæ, which are either wanting, or exceedingly faint in the other species. P. Asterias has a spot of bright yellow on the anterior edge of each side of the thorax; P. brevicauda has a fringe of duller yellow, extending fully half the length of the thorax. On the primaries the discal bar in P. Asterias is much narrower, and the inner row of spots smaller and bright yellow, the upper one in the row being divided; in P. brevicauda the spots are fulvous, the upper

side of the body black, the abdomen being furnished with two rows of yellow spots corresponding with those above, with several additional spots within near the tip; feet black. Primaries above brownish black, with a bar of yellow across the end of the discal cell; just beyond this is a row of eight spots, extending across the wing nearly parallel with the outer margin; the upper one, which rests on the subcostal vein, is yellow, elongated and irregular, with a blackish dot beyond the middle; the lower ones are *fulvous;* the second and third smaller than the first and of an elongated, triangular form, with the apex pointing inwards; the fourth, fifth and sixth are similar in shape, but larger, the latter with its apex partially wanting; the seventh spot is wider and slightly concave on both the inner and outer edges, the inner edge is broken; the eighth is long, narrow and irregular, with its lower edge close to the hind margin of the wing. Behind the upper spot in this row is a second yellow spot nearly round. Between these and the outer margin is a second row of spots, eight in number, but much smaller in size. These are all yellow, the three upper ones nearly round, the lower ones more or less elongated, the lowest contracted in the middle as if composed of two spots joined together; the fringe of the wing is also spotted with yellow, the spots corresponding in number and position with those forming the second row.

"Secondaries above brownish black, with a row of seven large spots nearly confluent beyond the middle, in continuation of those on primaries, all more or less triangular in form, the middle ones somewhat elongated; these spots are yellow above and at the sides, fulvous from near the middle to the outer edge; the fulvous marking is less distinct on the second and third spots; within the margin is a second row, all yellow excepting the upper one which is tinged with fulvous; the upper spot is oblong, the second nearly round; third, fourth and fifth lunular, nearly equal in size; the sixth similar in form, but much smaller; while the inner one is irregularly concave above, holding in the cavity the eye-like spot at the anal angle. On the outer edge are six yellow spots, larger and more striking than those forming part of the fringe on the primaries. The space between the two inner rows of spots is sprinkled with metallic blue atoms. At the anal angle is a round, red spot, with a black dot in it below the middle, and a crescent of bluish atoms above; tails *very short*, scarcely one-eighth of an inch long,—not more than half the length of those of P. Asterias.

"Under surface of wings somewhat paler in color, with spots corresponding to those above. The upper spot of the inner row on the primaries is tinted with fulvous; the spots composing the inner row on the secondaries are more decidedly and uniformly fulvous; the four upper spots in the second row are also streaked with the same color; the bluish atoms between the rows are partially replaced by green ones." Taken at St. John's, Newfoundland.

one is undivided. The inner row of spots on the secondaries are also entirely yellow in P. Asterias, smaller and very different in form from those on P. brevicauda. The second row of spots is also smaller in P. Asterias, and the red spot at the anal angle paler, with a smaller black dot in it, and a wider crescent of bluish atoms above. The length of the tail, which is one of the most striking points of difference, has already been noticed."

We have compared some interesting varieties of P. Asterias in the Museum of the Boston Society of Natural History, collected about Boston by Mr. Shurtleff, which approach (in the reddish hue of the spots, usually yellow, especially on the under side, and the shortness of the tail) the Newfoundland specimen kindly sent us by Mr. Saunders, and strongly suggest the inference, with which Messrs. Scudder and Sanborn agree, that P. brevicauda is a very remarkable local variety of P. Asterias.

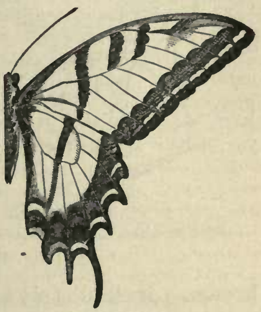


Fig. 180.

The yellow *Papilio Turnus* Linn. flies in June and July through woods and about lilacs. Its larva feeds on the apple and wild thorn; it is green with two eye-like spots on the thorax, and pupates in the middle of August. The black dimorphic ♀ form, P. Glaucus, is found in the Southern States. *P. Daunus* Boisd. (Fig. 180) originally found in Mexico, has been found in Kansas, near the Rocky Mountains, by Mr. James Ridings. He states that it strikingly resembles P. Turnus, but has longer antennæ, with longer, more curved fore-wings, besides differing in other characters. It expands nearly five inches. *P. Troilus* Linn. appears more commonly southward. The larva feeds on the sassafras and lilac trees, and was found by Mr. Saunders feeding, rolled up on a leaf, on the spice bush, August 3d. "Its length was about one and three-fourths inches, the body being thickest from the third to the fifth segments. The head is rather small, flat in front, slightly bilobed, dull flesh color, with a faint tinge of brown. The body is bright pea-green, with a yellow stripe across the anterior part of the second segment; edged behind with dull black. On the fourth segment are two prominent

eye-like spots, of dull yellowish or yellowish buff, encircled by a fine ring of black, and a large black pupil filling most of the lower portion. The posterior portion of this black pupil is encircled by a shining bluish black ring, the anterior portion of which strikes a little beyond the middle of the pupil; there is also a line of black in front of the pupil extending nearly across the yellow portion, and a pale pinkish spot in the upper part of the yellow which is edged with a slightly darker shade. On the fifth segment are two large, irregular spots of the same color, pale buff, encircled by a faint ring of black, and having a faint pinkish spot on the anterior portion of each; these spots are nearer to each other than those on the fourth segment, a portion of the space between the fifth and sixth segments being deep black; each segment, from the sixth to the eleventh inclusive, has four blue dots, encircled with black, those on the seventh, eighth and ninth segments being largest. On each side, close to the under surface, is a wide yellow stripe, gradually softening into the green above, and edged below with blackish brown. Immediately below the spiracles is a row of blue dots edged with black, one on each segment from the sixth to the twelfth inclusive. The under surface is dull, pale greenish, or yellowish white, having a decided reddish tinge as it approaches the yellow stripe on the sides. The feet partake of the same general color." *P. Philenor* Fabr. is black, with a greenish reflection towards the outer border, with whitish spots on the margin, and on the hind wings six whitish lunules. The larva is brown, with two lateral rows of small, reddish tubercles, and two long tubercles on the prothoracic segment. The chrysalis (Fig. 181, side and dorsal view) is grayish violet, yellowish on the back, with the head ending in a truncated cone.

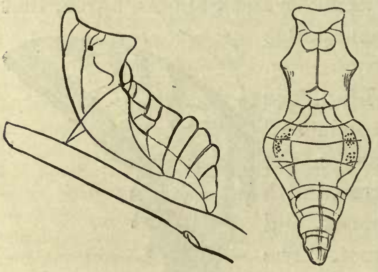


Fig. 181.

The genus *Parnassius* has short, thick antennæ, with a rounded club, and the fore-wings are much rounded at the apex; it inhabits mountains. *P. Smintheus* Doubleday, with three other species, is found in the Rocky Mountains.

The White Turnip, or Cabbage butterfly, *Pieris oleracea* Harris (Fig. 182; *a*, larva), is well known as being often destructive to cruciferous plants. In this genus, and its allies, the wings are rounded and entire on the edges, and are grooved on the inner edge to receive the abdomen. The greenish caterpillars are slender, "tapering a very little toward each end, and are sparingly clothed with a short down which is quite apparent, however, in Pieris oleracea." We have found the larvæ of this species on turnip leaves in the middle of August, at Chamberlain Farm in Northern Maine. They are of a dull green, and covered with dense hairs. They suspend themselves by the tail and a transverse loop; and their chrysalids are angular at the sides, and pointed at both ends. (Harris.) *Pieris oleracea* is white, with the wings dusky next the body, the tips of the fore-wings are yellowish beneath, and the hind wings are straw-colored beneath. The yellowish, pear-shaped, longitudinally ribbed eggs, are laid three or four on a single leaf. In a week or ten days the larvæ are hatched. They live three weeks before becoming full-fed. The chrysalis state lasts ten to twelve days. There is an early summer (May) and a late summer (July) brood. *Pieris rapæ* Schrank has been introduced from Europe and is now found in the vicinity of Quebec and the northern parts of New England.

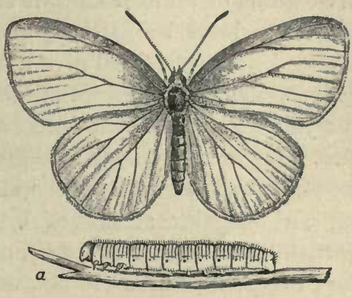


Fig. 182.

P. Protodice Boisd. and Lec. is found southward. The head of the chrysalis, kindly sent me by Mr. Saunders, is prolonged into a tubercle, which is equilaterally triangular, seen in outline, with two small tubercles near the base. On the thorax is a high, thin dorsal ridge, edged with red. On each side of the abdomen is a ridge, largest anteriorly, and rising into a thin tubercle on the second ring. There is a thin dorsal ridge on the posterior half of the abdomen. The tip is deeply excavated by a furrow extending the whole length of the terminal ring. There are seven rows of black dots on each ring.

It is pale whitish straw yellow throughout, with thick, black dots on the anterior half of the body. It is .70 of an inch in length. It also occurs in California.

The Sulphur-yellow butterflies, *Colias*, of which *C. Philodice* Godart, our most common butterfly, is a type, occur everywhere. There are two broods, one appearing in April and May, and the other in July. Mr. Saunders gives me the following history of this butterfly: "The female deposited her eggs on the 24th of July; they were very long, tapering at each end, with twelve or fourteen raised, longitudinal ribs, and smaller cross lines in the concave spaces between them. They hatched on the 31st. The freshly hatched larva is about a thirteenth of an inch long; the head is black, and the body dull yellowish brown. When five-eighths of an inch long, it is nearly the same as when mature; the head being dark green and slightly downy, with minute hairs, which also give a downy appearance to the whole body, which is also dotted minutely with paler points. There is a yellowish white stripe, on each side close to the under surface. Beneath, the body is slightly paler than above. The full grown larva is an inch long, and differs from the young in having an irregular streak of bright red running through the whitish lateral line. It feeds on the clover and lupine, and on the cultivated pea. It is not unlike a saw-fly larva in its appearance and movements, feeding on the upper surface of the leaves and twisting its body into a coil when disturbed. The chrysalis is about seven lines long, girt with a silken thread across the greatest diameter of the body, which is full and bulging on the sides. The head is pointed conically, with a purplish red line on each side, running to the tip and margined behind with yellow. The body is pale green, with a yellowish tinge, and a ventral line of a darker shade formed by a succession of minute, yellowish dots; a yellow stripe runs along the side on the five hinder segments. Beneath, on the seventh, eighth and ninth rings, is a blackish brown line on each side, deepening in color about the middle of each segment, and a dorsal line of dark green about the same length. It remains in the chrysalis state about ten days."

Mr. Scudder has described three species of this genus from the north. *C. Labradorensis* we have taken abundantly in

Labrador. It represents our C. Philodice. *C. interior* lives north of the Great Lakes, and *C. occidentalis* ranges from Fort Simpson to the Gulf of Georgia.

The species of a closely allied genus, *Terias* (*T. Lisa* and *T. Delia*), are much smaller and are more tropical.

The genus *Danais* has antennæ with a long and curved knob, the head and thorax are spotted with white, and the wings are round and entire. The caterpillars have projecting, thread-like horns, arranged in pairs on the top of the second and eleventh segments, and the body (D. Archippus) is banded with yellow, black and white. The oval chrysalids are short and thick and decked with golden spots. The larva of D. Archippus Harris feeds on the silk-weed, Asclepias, and matures in about two weeks, changing its skin three times, while the chrysalis state lasts for ten or twelve days. The butterfly appears from July to September.

A very beautiful and quite aberrant tropical genus is *Heliconia*, in which the wings are small, very narrow and often very transparent, while the antennæ are nearly as long as the body. The larvæ are either long, cylindrical and spinose (Acraea violæ), or furnished with several pairs of long fleshy appendages, and the chrysalids are often brilliantly spotted with golden and suspended by the tail.

According to H. W. Bates (Transactions of the Entomological Society, 1857), the venation of the wing in many species of *Mechanitis* and *Ithomia*, which are allied to Heliconia, varies in different individuals of the same species. The sexes have the closest resemblance in color and markings. They are very gregarious in their habits. The Brazilian "*H. Melpomone* varies in a curious manner. I have no doubt they are hybrids (*i. e.* the varieties), and I can almost point out the species with which it hybridates. Strange to say, the hybrids occur in one district and not in another, and one style of hybrids only occur in one district and not in the others, the species being equally abundant in all the districts."

Argynnis is readily recognized by the numerous round and triangular silver spots on the under side of the hind wings. The very spiny caterpillars have a round head, and the spines are branched, two of the prothoracic ones being the largest and

reaching over the head. The angular arched chrysalids have the head either square, or slightly notched, with a smooth thorax, while on the back of the abdomen are two rows of usually gold colored tubercles. They usually feed on violets, and may be found from May to July. *Argynnis Idalia* Drury is found the last of summer. *A. Cybele* Fabr. is found in the Middle States, and *A. Atlantis* Edwards in the White Mountain valleys and the colder portions of New England.

Mr. C. A. Shurtleff discovered the larva and pupa of the latter, July 17th, at Eastport, Maine, and being with him at the time, we made the following description of them: The larva is uniformly cylindrical, tapering alike towards each end of the body. On each side of the vertex of the head is a small low spine, giving the head an oblong shape when seen sidewise. The front is broad, somewhat square, flattened, with scattered hairs. On the first and second thoracic rings are two large subdorsal spines and minute lateral warts bearing small bristles, and on the hind edge of these rings are two large spines. On the third thoracic ring are three large spines. On each abdominal ring are six stout spines of the same size and placed equidistant on the upper surface. The bristles on the spines are nearly one-half as long as the spines themselves. Small papillæ, giving rise to bristles, are scattered over the body, with a row of them above the abdominal feet. The triangular anal plate is small, papilliform and prominent. The larva is dark velvety purple, the base of the head being of a pale horn color; the body beneath is scarcely paler than above; the spines are pale livid on the basal half. They were full-fed and ready to pupate July 17th. The head of the pupa is square in front. On the prothorax are two subdorsal spines, and an elevated mesial ridge on the mesothoracic ring, rising highest behind. At the base of each wing is a sharp, conical, prominent papilla, immediately succeeded by a broad, thin-edged dilatation, constricted and appressed to the base of the abdomen; this is the internal angle of the wings. On the abdomen are two lines of subdorsal sharp papillæ, one on each side. The wings extend to the fifth abdominal ring, and from this point the abdomen rapidly tapers to the tip. The surface of the body is wrinkled with conspicuous black spiracles. Its general color is chest-

nut brown, mottled with black; the wings being black at the base. The sexes of the rare and superb *A. Diana* Cramer differ remarkably, the male being dark velvety brown, with a deep orange border, while the female is blue-black, with lighter blue spots and patches on the border of the wings. It has been taken in West Virginia, Georgia and Arkansas.

A. Aphrodite (Fig. 183*) abounds in the Northern States. According to Scudder, it is double-brooded, appearing about the middle of June, and fresh specimens late in August. *A. Montinus*, a more diminutive species, was discovered by Mr. Scudder on the lower half of the barren summits of the White Mountains. Allied to this last species by their size, are *A. Myrina* Cramer and *A. Bellona* Fabr. found in damp meadows late in summer. A. Myrina has tawny wings bordered with black above, and expands from one and three-fourths to one and eight-tenths of an inch. A. Bellona differs from the other species by not having any silvery spots on the under side of the wings. Mr. Saunders has reared A. Myrina from eggs deposited June 24th, by a specimen confined in a box. "The egg is pale green, elongated, shaped something like an acorn, with the base smooth, convex and the circumference striated longitudinally, with about fourteen raised striæ which are linear and smooth; the spaces between are about three times wider than the striæ, depressed, concave in the middle, and ribbed by a number of cross lines, fifteen to twenty between each striæ, and distinctly indented. The egg is contracted at the apex, the striæ protruding at the tip all around a little beyond the body of the egg. The larva hatched in six or seven days, and when fresh from the

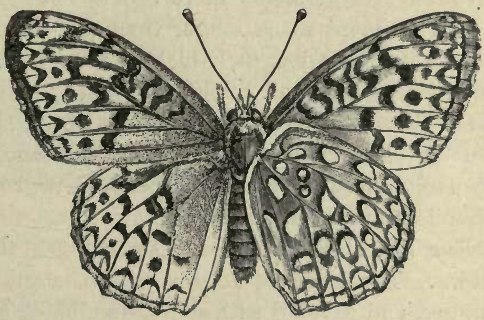


Fig. 183.

* The upper side of the wings are figured on the left side, and the under side on the right, in this and in FIGS. 184 and 188.

egg was about one-tenth of an inch long. The head is medium sized, black, and shining; the body above is dark brown, with transverse lines of a paler color, especially on the anterior segments; it is thickly covered with stout hairs of a pale brownish color; between the first and second moult it is one-fourth of an inch long. The head is bilobed, shining, black and hairy, and the body above is greenish black, the greenish tinge most apparent on the second and third segments, with a few small yellowish dots along each side, and transverse rows of strongly elevated, black tubercles, emitting numerous short, black hair-like spines.

"The under surface is similar to the upper; the feet are black and shining, and the prolegs are black, tipped with a paler hue. After the second moult there are two fleshy tubercles on the second segment much longer than the others, being three or four times their length, which are covered throughout with small hair-like spines. The yellowish spots along the sides of the body assume more of an orange tint, and there are one or two faint, longitudinal streaks of the same color along the sides close to the under surface, and between the rows of large, raised tubercles, are many smaller ones which are also black and appear but slightly raised. August 7th the larva was full-grown. The head is, at this period, slightly bilobed, black, shining, and covered with short, fine, black hairs.

"The body above is dark greyish brown, beautifully spotted and dotted with deep velvety black; the second segment, has two long, fleshy horns, yellowish white at base, black above, covered with minute, blackish, hair-like spines. The third and fourth segment, have each four whitish spines tipped with black, those on the sides placed on the anterior portion of the segment, those above about the middle. All the other segments have six whitish spines, excepting the terminal one, which has four. All the spines have fine branches of a black or brownish black color and are about one-third the length of the fleshy horns on the second segment. A pale line extends along each side from the fifth to the terminal segments close to the under surface. The under surface is brownish black, darker on the anterior segments; feet black and shining; prolegs brown, with a shining band of brownish black on the outside.

The duration of the pupa stage was ten or eleven days." The pupa, received from Mr. Saunders, has two large, conical tubercles in front of the insertion of the antennæ, and two acute tubercles on the prothorax. The thorax is acutely bituberculated on the sides, with an acute thin dorsal ridge, on each side of which are two small, sharp tubercles. Along the back of the abdomen are two rows of tubercles, those on the third abdominal ring being much larger. It is half an inch long, and pale ash, with black dots and irregular lines.

Fig. 184.

Melitœa differs in not having silver spots beneath, while the caterpillars are covered with blunt tubercles which give rise to short stiff bristles. They feed on different species of plantain. The chrysalids are like those of Argynnis, but spotted with black or brown, and not with golden.

Fig. 185.

Melitœa Phaeton Drury (Fig. 184) is found in damp bogs. We have taken the young larva less than one-half of an inch long, early in spring under leaves, where it had doubtless hibernated. The mature larva (Fig. 185, enlarged, the specimen from which the drawing was made, is too contracted, the head being drawn in unnaturally; fig. 186, pupa) is cylindrical, and the head is slightly angulated. There are nine rows of black spines which are fleshy and surrounded at the tips with rather long, thickset spinules. The head and thoracic and last three abdominal rings are black; the rest of the body being deep orange, with black lines between the spines, and dots along the side. Towards the last of May and early in June it changes to a chrysalis, which is white with a slight bluish tinge, with yellow papillæ, and scattered black

Fig. 186.

spots, giving it a gay and variegated appearance. The butterfly rises from cold, swampy places the last of June and early in July. Its wings are velvety black, with orange red crescents and spots. It expands from two to two and a quarter inches, being our largest species.

M. Tharos Boisd. and Leconte is a very abundant species in New England. There are two broods, one appearing in June and early in July, and the second one late in August and September. It has short, broad wings which are tawny orange above, with black, irregular lines and spots; it expands from one and three-tenths to one and a half inches.

Mr. Saunders has sent us a remarkable and undescribed butterfly, under the name of *Melitœa Packardii* Saunders, with the following description: "It resembles M. Tharos in size, and expands 1.42 of an inch. The palpi are pale brown above, yellowish below; antennæ black above, dotted with white and tipped with red; below white tipped with red. Head, thorax and abdomen, black above, clothed with brownish hairs; white underneath; feet brownish yellow; wings above brown, with a cupreous tinge, sprinkled with fulvous atoms, with a wide band of dark brown on the outer margin, faintly edged on each side with black. The primaries have a fulvous macular band a short distance from the base, extending nearly across the wings, and a patch of the same hue a little beyond and towards the front margin. Beyond the middle is a wide band of the same, divided by the veins into a series of seven spots; the upper one is very small, a mere dot with a whitish hue; the second is much larger; the third and fourth are nearly uniform in size, larger and more elongated than the second; the fifth and sixth are the largest and wider and longer than any of the upper ones; the seventh is nearly of the same width as the sixth, but not more than half the length; the fringe is dotted with white, especially about the tip.

"On the secondaries a wide fulvous patch covers the inner part of the wing, extending from near the base to near the middle of the wing, and bounded towards the inner margin by a brown edging; within this patch are three rounded blackish spots, one most distinct about the middle, the others near the inner margin and partly lost in the brown edging of the wing.

Beyond this is an imperfect band of fulvous spots, in continuation of those on the primaries; the upper ones faint and indistinct, and two of the lower ones prominent and nearly round; the last small and linear. The inner margin is edged with fulvous, having a yellowish tinge which encroaches on the outer brown marginal band at the anal angle. The fringe of the secondaries is dotted with dull white. The primaries below are fulvous, with a single wavy, brown line across the wing a short distance within the outer margin; base yellowish, costal margin sprinkled with dark brown atoms, and a streak of the same along the middle of the wing near the hind margin. At the tip is a yellowish patch, occupying the space between the brown line and the margin, and within this, one of silvery white nearly equal in size. Below the white are three indistinct, yellowish patches, the lower one extending to the outer margin; a large patch of yellow at the lower corner where the outer and hinder margins meet. The secondaries below are yellowish from the base to near the middle, with streaks and spots of brown; the yellowish color extending down the inner to the hinder margin. Beyond the middle the wings are silvery white, sprinkled with yellow and brown scales, divided by the brown veins and partially crossed by an irregular streak of brown. There are also two brown patches on the hind margin, the smaller one nearly round and occupying the space between the first and second median venules; the larger being irregular and resting on the median vein, and extending across the third to the second subcostal venule. It was taken near Grimsby, Ontario County, Canada."

Melitæa Œnone Scudder is rarely found in Maine and Massachusetts; it is pale fulvous above, with blackish brown markings, and expands from one and three-fifths to one and four-fifths inches. *M. Harrisii* Scudder may be readily distinguished from *M. Œnone* by the under surface of the hind wings being cinnamon-red, with bands and spots of white margined with black. It expands one and three-fourths inches and is found in New England, though rather a rare species. The larva has been reared in Norway, Maine, by Mr. S. I. Smith. It feeds on Diplopappus umbellatus, pupating from the middle to the last of June, and remaining in the chrysalis state from ten to

sixteen days; the butterfly appears from June 20th to Aug. 1st. The larva (Fig. 187) has also been discovered in Vermont by Mr. P. S. Sprague, and we describe it briefly from an alcoholic specimen, in the collection of Mr. Sanborn. It is cylindrical, with six acute, small tubercles on each side of each thoracic ring, while on the abdominal rings the four dorsal tubercles are larger and remarkably boot-shaped, the toe being formed by a lateral prolongation of the tubercle, and the heel is also well formed, from which arises a short bristle. The specimen is dark, with a lighter stripe along the back on each side of the median line of the body. Its length is .80 of an inch.

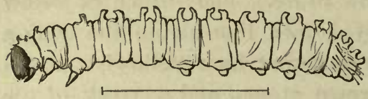


Fig. 187.

M. Chalcedon Doubleday is found in California and the Rocky Mountains, while *M. Anicia* Doubleday, the under side of which is much like that of Chalcedon, occurs not only in California and the Rocky Mountains but also in Kansas. *M. Texana* Edwards is a Texan species expanding one and one-half inches.

In *Vanessa* the wings are notched and angulated or tailed on the hind edges, while the palpi are long and beak-like. The larva is cylindrical and stoutly spined, the spines being long and branched. The caterpillars are gregarious during the early stages. "The head of the chrysalis is deeply notched, or furnished with two ear-like prominences; the sides are very angular; in the middle of the thorax there is a thin projection, in profile, somewhat like a Roman nose, and on the back are two rows of very sharp tubercles of a golden color." (Harris.) *Vanessa Antiopa* Linn. is one of our most abundant butterflies, being much more common in this country than in Europe, whence it has probably been imported. Its wings are purplish brown above, with a broad buff yellow border in which is a row of pale blue spots. The butterfly hibernates, appearing before the snow is off the ground. It is seen until June, and then not until the middle of August. The larva is black, spotted minutely with white, with a row of eight dark, brick-red spots on the back. The chrysalis is dark brown, with large tawny spots around the tubercles on the back. The caterpillar defoli-

ates the willow, poplar and Balm of Gilead. *Vanessa Milbertii* Godart is much smaller and is rather rare. It occurs about roadsides in May, July and August. The larva feeds on nettles. Mr. Saunders informs me that "it was found feeding on the nettle, nearly full grown, July 26th. It was from one to one and one-eighth inches long. The head is black, thickly covered with fine, brownish white hairs, and sprinkled with many minute whitish dots. The body is black, thickly sprinkled with whitish dots and with small, fine, white hairs, each segment, excepting the second, with a transverse row of branching spines. A greenish yellow lateral line runs close to the under surface, with a second broken line of a brighter yellow color. All the spines and their branches are black, excepting the lower row on each side from the fifth to the twelfth segment, springing from the greenish yellow lines; these are of a greenish yellow color. Under surface dull greenish, minutely dotted with whitish dots. There is a wide, central, blackish stripe covering anteriorly, nearly the whole of the under surface." *V. Californica* Boisd. is bright fulvous, with three black bands on the anterior edge of the fore-wings, and there are no black crescents in the black border of the wings.

The genus *Grapta* differs from the preceding in its deeply incised wings, its smaller size, and red and brown colors. The under side of the hind wings has usually a silvery or golden dot and curved line, or both, imitating different punctuation marks. *Grapta interrogationis* Doubleday is one of the largest species, and has a golden semicolon beneath. It is found in May, August, and in autumn. The caterpillars injure the foliage of the elm and lime trees, and also the hop vine, sometimes defoliating the whole vine. The larva has been found, by Mr. Saunders, feeding on the hop, August 7th. "When full grown its length is one and one-fourth inches. The head is reddish black, flat in front and somewhat bilobed, each lobe tipped with a tubercle emitting five single, black, pointed spines; it is covered with many small, white, and several blackish tubercles. The body is cylindrical, black, thickly covered with streaks and dots of yellowish white; the second segment is without spines, but with a row of yellowish tubercles in their place; the third segment has four branching spines, all black,

with a spot of dark yellow at their base; and on the fourth segment are four spines, as there are on all the others, excepting the terminal, which has two pairs, one posterior to the other. The spines are yellow, with blackish branches, excepting the terminal pair which is black; and there is a row of reddish ones on each side. The under surface is yellowish grey, darker on the anterior segments, with a central line of blackish and many small, black dots." The chrysalis state lasts from twelve to fourteen days. It is ash brown, with the head deeply notched, and eight silvery spots on the back. *Grapta c-argenteum* Kirby (Fig. 188, G. Progne Harris) is a small species with a silvery L in the middle of the under side of the hind wings. It is our most common species northward. It appears the last of summer. The larva lives on the hop and elm. *Grapta comma* Doubleday is more common southward. It is known by having a silvery comma in the middle of the hinder wings. The caterpillar lives on the hop and elm. Mr. W. H. Edwards has found the larvæ on the broad-leaved nettle. He says "my attention was first attracted by observing certain leaves drooping, and more or less eaten. On the under side of these I usually found the caterpillar inactive, and never more than one upon the same plant. The half-grown larvæ were black, with a yellowish stripe along the side from the third segment to the tail, and with yellow stripes across the back, and spots of the same color at the base of the dorsal spines, which were yellow, tipped with black. The mature larvæ were white, mottled or striped with grey or ashen, and with red spiracles."

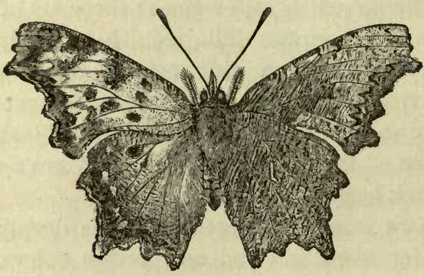


Fig. 188.

The chrysalis is brownish gray or white, variegated with pale brown, and ornamented with gold on the tubercles. The fly appears in May, July, August and September. In the colder and mountainous portions of New England and New York, these species are replaced by the *Grapta Faunus* of Edwards,

who states that "comparing Faunus with c-album, the former is deeper colored by many degrees; it is one-fifth larger, the black spots and margins much heavier, and, owing to this and the depth of the ground-color, the general hue of the surface is much darker than either c-album or any of the American species." The under side of G. Faunus is beautifully marbled in several colors.

The genus *Pyrameis* differs from Vanessa in having the wings simply scalloped, not notched; beneath, they are not marked with metallic colors, and the long, tapering palpi curve upward. The larvæ are covered with branched spines, corresponding in size, and often wanting on the first and last segments; the head is heart-shaped. They are solitary, hiding under a rolled leaf or spinning a slight web, and hang by the hind feet alone when about to transform. The chrysalids are angular on the sides, with two or three lateral rows of sharp, golden tubercles, and a short, thick tubercle on the top of the thorax. *P. cardui* Linn. feeds on thistles and the sunflower, the hollyhock, burdock and other rough-leaved plants, in June and July. It remains in the pupa state twelve days, the butterfly appearing in Maine, about the 20th of July. *Pyrameis Huntera* Fabr. has much the same habits, while *P. Atalanta* Linn. feeds on the nettle. These species are all double-brooded, first appearing in May and then in July, August and September.

Junonia is closely allied to Vanessa. *J. cœnia* Boisd. and Lec. is found in the Southern States, the West Indies, Mexico and California.

In *Limenitis* the antennæ are very slender, and the hind wings are scalloped, while on both wings the discal area is open. The caterpillar and chrysalis are like those of Danais. *L. Misippus* Fabr. (Fig. 189) is tawny yellow above, and of a paler yellow beneath, with a broad, black border, spotted with white, and black veins. It expands from three to three and a half inches and flies from June to September. The larva is pale brown, variegated with white on the sides, and sometimes with green on the back; the prothoracic ring has two slender, blackish, spinulated horns, and on the tenth and eleventh rings are short tubercles. It feeds on the poplar and

willow. The pupa is known by a thin, almost circular, projection standing out from its back. The young larvæ winter in cases "composed of the leaf of the willow, on which the larva feeds, neatly joined by its longest opposite margins, so as to form a cylindrical tube closed at one end and lined with silk." (Trouvelot.) *L. Ephestion* Stoll is blue black, with three black lines on the hind edges, and just within the outer border is a row of orange colored spots. It lives on the scrub-oak (Quercus ilicifolia) in June, and also on the whortleberry and the cherry. *Limenitis Arthemis* Drury is smaller and has an oblique, broad, white band, crossing both wings. It is common in the White and Adirondack Mountains, where it is double brooded, appearing late in June, and again late in August.

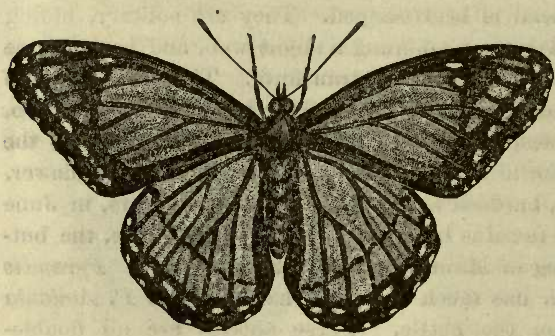


Fig. 189.*

The superb and regal genus *Morpho* is the Atlas among butterflies. The broad wings spread nearly six inches, and are usually of a brilliant blue above, and brown beneath, with eye-like spots. *Morpho Menelaus* Linn., from Brazil, expands five and a half inches. *M. Polyphemus* Chenu is a Mexican species. *M. Epistrophis* Hübner is of a delicate pale green, with two rows of lunate brown spots on the hind wings. The apex of the fore-wings is brown, and the discal spot is connected with the brown costa. It inhabits Brazil.

The genus *Satyrus*, and its allies, *Chionobas*, *Hipparchia* and *Neonympha*, are wood brown and ornamented, especially beneath, with eye-like spots, and have the wings entire, with the veins of the fore-wings swelled at their base, and the discal area open on the hind wings. They have a short, quick, jerky flight. The caterpillars are green and smooth, spindle-shaped, or cylindrical, tapering at both ends; the hind end is notched,

* FIGS. 189, 190 and 198, are from Tenney's Zoölogy.

and the head entire or notched. They live mostly on grasses. "The chrysalis is either oblong and somewhat angular on the sides, with the head notched, and two rows of pointed tubercles on the back, or short and rounded, with the head obtuse." (Harris). *Chionobas* is found on Alpine summits and in the Arctic regions and on subarctic mountains. *C. semidea* Say (Fig. 190; Fig. 191, hind wing) lives on the summit of Mount Washington. It feeds on lichens.

Fig. 190.

Mr. Scudder, has in the accompanying figures, closely exhibited the differences between the Alpine and Arctic species of Chionobas. *C. Jutta* Möschler (Fig. 192) we took in Northern Labrador; it extends as far south as Quebec, according to Edwards. *C. Chrixus* Doubleday, (Fig. 193) is found on Pike's Peak, Colorado Territory; *C. Calais* Scudder (Fig. 194) is found on Albany River, Hudson's Bay; *C. Bore* Schiödte (Fig. 195) we have collected in Hopedale, Labrador, as also *C. Œno* Boisd. (Fig. 196).

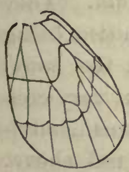


Fig. 191.

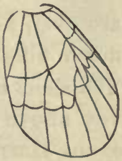


Fig. 192.

Satyrus Alope Fabr. is our largest species. It is dark brown, with a broad, ochre-yellow band beyond the middle. It is abundant in open fields in July and August. The pale green larva is striped with dark, the head is round, and the tail is forked. The chrysalis is rather long, rounded on the sides and with the head notched. *S. Nephele* Kirby is the more

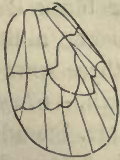


Fig. 193.

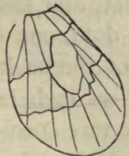


Fig. 194.

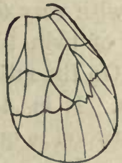


Fig. 195.

Fig. 196.

northern form, and in the upper Middle States, as about the Catskill mountains, occupies higher ground, according to Mr. Edwards, while S. Alope, which prevails southward, is found in the lowlands and valleys. S. Nephele is smaller, darker, and

there is no yellow band on the fore-wings, though, sometimes, each eye-like spot is surrounded by a yellowish diffuse ring.

Neonympha Eurytris Fabr. flies low, with a jerky sort of motion, in thick woods, in June and July. The larva is like that of S. Alope, while the chrysalis is shorter with the head obtusely rounded. The adult is dark brown, with two black eye-spots, pupilled with a lead-colored dot, and surrounded with an ochre-yellow ring. On the hind wing is a smaller, similar spot. It expands one and seven-tenths of an inch.

The aberrant genus *Libythea*, with its long, snout-like palpi, reminds us of the Pyralids. It is small and the wings are irregularly notched. *L. Bachmanii* of Kirtland is not a common butterfly. It occurs southward, and in Central America and the West Indies.

The small, delicate Theclas and Lycænas are often of great beauty and interest. The palpi are elongated, the wings entire, and the hind pair are often once or double tailed. The larvæ are slug-like, as when moving on their short feet, sixteen in number, they seem rather to glide than walk. They are oval, flat below and rounded above, both extremities being much alike, with the small head retracted within the body. The short and thick chrysalids are flat beneath, but very convex above and rounded at each end. *Chrysophanus Americanus* Harris, our most abundant form, is coppery red above. Its green larva feeds on the sorrel, and there are three broods of butterflies in the year. The chrysalis is usually suspended under a stone. One sent by Mr. Saunders, is smooth, with no fine hairs. The head and thorax, including the wings, is dull reddish brown, dotted with black; the abdomen is much lighter cinereous, with very distinct, and irregular black dots, and a lateral row of twin black dots, one dot being a little behind its mate. On the middle of the back are three rows of smaller black dots. It is .45 of an inch in length. *Chrysophanus Thoe* Westwood is quite a rare species. Mr. Saunders describes the eggs as being "nearly round, a little flattened at the apex and flattened also at the base, where it is fastened to the box. They are greenish white, and thickly indented; at the apex is a considerable depression; immediately around this, the indentations are small, growing larger towards the base."

The genus *Lycæna* is azure blue throughout, with dark markings. *Lycæna neglecta* Edwards (Polyommatus pseudargiolus Harris) is very common about the Kalmia and Rhodora in May, and a new brood appears in June and July. It has been reared by Mr. Saunders, from whom I have received the pupa, which is a little hairy, being much smaller than in Thecla Acadica and paler ashy. It is spotted quite thickly with black blotches, and on each side of the abdomen is a subdorsal row of rather large, black, contiguous blotches, more distinct than in T. Acadica. It is .30 of an inch long.

L. comyntas Harris is quite common southward. It differs from the other species in having a little tail on the hind wings, at the base of which are two deep, orange-colored crescents. It flies in July and August. The caterpillar lives on the Lespedeza. It is green with three darker stripes. The brown chrysalis has three rows of black spots on the back.

Thecla differs from the two preceding genera, in its conspicuous tails and the longer clubs of the antennæ and its dusky brown hues. The larvæ are longer and flatter, and they usually live on trees. *Thecla humuli* Harris feeds on the hop-vine. It flies in July and August. *Thecla niphon* Godart, a dusky rust-red butterfly, feeds on the pine. The larva is green, with a dorsal yellow stripe, and, a white one on each side. It changes to a short, thick, greyish pupa, with two rows of blackish dots, and beyond these a row of rust-red ones. Mr. Saunders has sent us the following description of the caterpillar and chrysalis of *Thecla Acadica* Edwards, found by him at London, Canada West, feeding on the willow, June 11th and 18th. "It was .63 of an inch in length, with a very small, pale brown head, withdrawn within the prothoracic segment, when at rest. The body is rather dark green, and is thickest from the mesothoracic to the sixth abdominal segment. There is a darker green, dorsal line, the dorsal region being flat, rather wide, and edged on each side with a raised, whitish yellow line, and the sides of the body are inclined at almost an acute angle, and striped with faint, oblique lines, of a greenish yellow. A whitish yellow line borders the under surface, beginning at the anterior edge of the second segment (the head is, for convenience, counted as a single ring, or segment) and

extending entirely around the body. The chrysalis is .32 of an inch long, and .15 wide. It is fastened with a silken thread. The abdomen is thickened and somewhat raised. It is minutely hairy, pale brown, with many dots and patches of a darker color; the upper edge of the wings being quite dark, with a dark ventral stripe, and four or five short, dark lines on the side. It remains in the chrysalis state eight or nine days, the caterpillar turning dark July 3d, just before pupating." The body, especially the abdomen, is thicker and fuller than in Chrysophanus Americanus.

Thecla Mopsus Hübner is found in New England and Canada. Mr. Saunders sends me the following description of the larva taken June 9th, by beating bushes, at London, Canada. "It was .40 of an inch in length. The head is small, of a shining black color, with a pale stripe across the front just above the mandibles, and is drawn within the second ring when at rest. The body above is green along the middle rings, deep rose color at each extremity, and is thickly covered with short, brown hairs. The second segment is rosy above, greenish yellow at the sides, with an edging of the same color in front; the third segment is entirely rose colored; from the third to the tenth segments is a dorsal stripe of rose which is wide on the fourth, fifth, eight and ninth segments, but narrow and linear on the intermediate ones; on the tenth segment the green encroaches on the rose color on the sides of the body, extending more than half-way upon the segment behind the tenth. The body is rose colored with a dorsal streak of a darker shade. The rose color at each extremity is united by a rosy line along each side close to the under surface which grows fainter on the middle segments. The under surface is dull green, with a yellowish tint; the feet and prolegs (abdominal legs) are yellowish green. June 24th, the larva has now become quite large and will probably soon go into the chrysalis state. I found it would readily eat the plum and cherry.

"Its length is now .70; its width about .20 of an inch. The head is very small, bilobed, black and shining, with a streak of dull white across the front above the mandibles, which are reddish brown. The body above is dull green, with a yellowish tint, especially on the anterior segments, which are

thickly covered with very short, brown hairs, scarcely visible without a magnifier; these hairs arise from small, pale, yellowish dots which appear slightly raised ; there is a dorsal streak of dark green arising from the internal organs showing through the semitransparent skin. There is a patch of dull pink, or rosy color, on the anterior segments from the second to the fourth inclusive; it is faint on the second ring, and covering but a single portion of its upper surface, and nearly covering the dorsal crest on the third segment, and reduced again to a small, faint patch on the fourth. On the posterior segments is a much larger rosy patch, extending from the hinder part of the ninth segment to the end of the body. The hinder part of the ninth segment is merely tinged. On the tenth segment it becomes a rather large patch, widening posteriorly. Behind this the body is entirely covered with rosy red. The sides of the tenth segment, close to the under surface, have a streak of the same color, and there is a faint continuation of this on the ninth segment. The head is drawn within the second segment when at rest. The second segment is smaller than the third; there is a wide dorsal crest, or ridge, from the third to the tenth segments inclusive; behind this the body is suddenly flattened, the sides suddenly sloping. The under surface is yellowish green, with a few very fine brownish hairs; the feet and prolegs are greenish, semitransparent.

"On June 29th it fastened itself to the lid of the box, changing to a chrysalis July 1st, which was .45 of an inch in length, and its greatest width .20 of an inch. The body is pale brown and glossy, with many small, dark brown or blackish dots distributed over the whole surface; they are thicker along the middle above, with a faint, imperfect, ventral stripe from the seventh to the eleventh segments; the surface is thickly covered with very short, brown hairs, invisible without a magnifier. The imago appeared July 13th."

Mr. Saunders has found the larva of *Thecla strigosa* Harris, a rare species in Canada and New England, feeding on the thorn, Cratægus, July 13th. "The head is small, greenish, with a faint tint of brown, and a black stripe across the front below the middle, and a patch of white between this stripe and the mandibles, which are brownish black above. The body is of a

rich velvety green, with a yellowish tinge, slightly paler between the segments, and a dorsal stripe of a darker shade, centred along the middle segments with a faint, yellowish line. The anterior edge of the second segment is yellowish brown, with a few dots of a darker color. The body is thickly covered with minute hairs which are brown above and white below, being scarcely visible to the naked eye. The body is flattened above (dorsal crest not bordered with yellow as in T. Acadica), steeply sloped at the sides, where it is striped with faint oblique lines of yellowish, two or three on each segment. The two last segments have a patch of yellowish on each side, making the dark dorsal line appear much more prominent. A faint yellowish line close to the under surface from the fifth to the terminal segments. The under surface is bluish green, with a darker patch on the last two segments.

"The chrysalis changed June 19th, and is nearly oval in form. The head-case is rounded, and the body is dark reddish brown, with black markings thickly covered with fine, short, whitish hairs, rather more numerous on the anterior and posterior segments. Anterior segments with many thickly set patches of blackish, and a dark ventral line from the sixth to the twelfth segments. It is bound by a few silken threads on the anterior portion of the first and second segments."

The accompanying cut (Fig. 197) represents the pupa of a Thecla, found in July by Mr. Sanborn, on the Glen road to Mount Washington. The body is smooth and tapers gradually from the mesothorax, and the venation of the wings is very apparent. Another pupa, probably of Thecla, found by Mr. Sanborn, is very different, being much stouter, and thicker through the abdomen, by a third of its diameter, than the chrysalis figured. It is rough and covered with short, fine, stiff hairs; the tegument is so thick, that there are no traces of the veins of the wing, while the sutures between the segments and the appendages are not nearly as distinct. The larva, according to Mr. Sanborn's notes, was found feeding upon the White Pine, July 13th. "It was .45 of an inch long; the head was retracted, yellowish, and the body pale, transparent green, with four longitudinal, white stripes, and one transverse, lozenge-shaped

Fig. 197.

patch, of the same color, on the eleventh segment. The rings were all somewhat elevated in the middle of their diameter and thinly covered with yellowish brown, short hairs." He did not succeed in rearing the butterfly, but this description will be useful to any entomologist who may be fortunate enough to rear it hereafter.

The Hesperians, or Skippers, are a large group of small, dark, dun-colored butterflies, whose antennæ have the knob curved like a hook, or ending in a little point bent to one side, reminding us of the antennæ of the Sphinges. They are moth-like in their motions, form, and larval characters. They are stout bodied, with large heads and prominent eyes, and thick palpi, almost square at the end. The larvæ are spindle-shaped, naked, and with a remarkably large head. They are solitary, and often hide in folded leaves like the *Tortricidæ*, transforming in a rude cocoon of dead leaves or stubble, held together by silken threads. The pupæ are somewhat conical, like those of moths, smooth and generally covered with a bluish white powder. They are fastened by the tail and a slight band of threads within their rude cocoons. We have many species in this country; the largest forms occurring southwards.


Fig. 198.

Eudamus Tityrus Cramer feeds on the locust and is our largest species northward. *E. Bathyllus* flies in June and July. It feeds on Glycine and Hedysarum in May and June. In *Hesperia* the knobs are shorter, and end in a point turned sidewise. The upper wings are raised, and the lower spread out flat when at rest. The chrysalis has a long tongue-case free at the end, in this respect showing a transition to the hawk-moths. They are snuff-brown, with dark spots.

Mr. W. Saunders has been very successful in raising the larvæ of *H. Hobomoc* Harris and other butterflies and moths, by watching for the fertile eggs in captured specimens, which are often deposited on the sides of the collecting box. The food-plant of the larvæ can usually be discovered after experimenting with those plants on which other species of this or allied genera are known to feed. "The egg, deposited June 17th, is nearly round, flattened on the lower side, and of a

pale green color. Under the microscope it appears plainly reticulated, with fine, six-sided markings, strongly resembling the cornea of a fly's eye. The larva on finding its way out, June 27th, began to eat the egg-shell at the centre above. It feeds on grass, on the inside of the leaves near the joints, drawing portions of the leaves together with silken threads. When placed on a strongly ribbed blade of grass, it spins a few threads from rib to rib, and stations itself behind the threads. By the 14th of July the caterpillars were three-eighths of an inch long and resembled those of H. Mystic of the same age." Mr. Saunders did not succeed in raising the caterpillars to maturity as they were unfortunately lost.

The most abundant species in New England is *A. Wamsutta* Harris (Fig. 198) which frequents roadsides throughout the summer. According to Mr. Saunders' notes, from "eggs deposited July 10th, the young larva was hatched July 24th, the eggs growing darker about two or three days previous. The egg is pale greenish yellow, or yellowish green, strongly convex above, and flattened at the place of attachment. The flattened portion is slightly concave and very faintly reticulated under a power of forty-five diameters.

The young larva, when first hatched, is about the same as that of Mystic and Hobomoc, probably .10 of an inch, and is scarcely distinguishable from them, excepting that it is slightly darker in color. The head is large and prominent and of a shining black color. The second segment has a ring of brownish black, encircling it above. The body is dull brownish yellow, very faintly dotted with black, each dot emitting a single, rather long, brownish hair. The under surface is rather paler than the upper.

Mr. Saunders has also reared the larva of *H. Mystic* Edwards from the egg, which is "strongly convex above, flattened below and depressed in the centre of the flattened portion. Under a magnifying power of eighty diameters, the surface is seen to be faintly reticulated; it is pale yellowish green. The eggs were deposited about the 20th of June and hatched on the 28th and 29th of June. When hatched it was .10 of an inch long, with a large, black head, and was white, becoming yellowish brown, especially towards the end of the body. It feeds

on grass, and at this stage can scarcely be distinguished from the young larva of H. Hobomoc. When an inch long the head is not large in proportion to the body, though it is prominent and wider than the second segment; it is dull reddish brown and black posteriorly. The body above is semitransparent, dull brownish green, with minute, whitish hairs, similar to those on the head, with a dorsal line and many darker dots over the surface. The second segment is pale whitish, with a line of brownish black across the upper surface, with a faint, pale, lateral line close to the under surface: the terminal segments are paler than the rest of the body. The feet are whitish, semitransparent. This species is found from Canada to Maryland.

Sphingidæ Latreille. The Hawk-moths or Humming-bird moths are among the largest and stoutest of Lepidoptera. The body is very stout, spindle-shaped, with narrow, powerful wings. Their flight is, consequently, exceedingly swift and strong. The antennæ are prismatic in form and thickened in the middle. The tongue, or maxillæ, is remarkably long, so that the insect is able, while on the wing, to explore the interior of deep flowers. This habit of remaining for a considerable time poised in the air on their rapidly vibrating wings, causes them to be mistaken for humming-birds. At rest the wings are folded, roof-like, over the body. The larvæ have sixteen legs, and on the last segment is an acute horn, sometimes represented by a simple tubercle. At rest they stand with the forepart of the body elevated in a supposed Sphinx-like attitude. The larvæ descend into the earth and transform, often in rude, earthen cocoons, moulded into form by the pressure of the body. The tongue-case is usually free.

There are between 300 and 400 species known, a large part of which are tropical American. Most of the species fly in June and July. The larvæ transform in the latter part of August and in September.

In *Ellema* the body is small. The head is small, narrow and somewhat tufted, and with small eyes. It might be passed over on a hasty view for a Noctuid. The larva of *Ellema Harrisii* Clemens is green, has no caudal horn, and lives on the pine.

Mr. Saunders writes me that he has found it feeding on the pine, about the middle of September. "It is two inches long, the body being smooth and nearly cylindrical and thickest in the middle of the body. The head is large, pointed above, flat in front and green, with a yellow stripe on each side. The body is bright green, with a dorsal row of dark red spots on the fifth to the twelfth segments inclusive, with a bright yellow stripe on each side of the reddish spots and a lateral white stripe mixed with yellow." The moth is a very small, ash grey species, only expanding two inches. It frequents flowers at dusk in June.

The genus *Sphinx*, as now limited by systematists, is much larger bodied, with a long and narrow head, small eyes and long and narrow wings. The head of the larva is rather large, semi-oval and flattened in front. The body is cylindrical, smooth and obliquely banded on the side, with an arching, caudal horn. It transforms in a subterranean earthen cell. The tongue-case of the pupa is short and free, instead of being soldered to the body. *Sphinx gordius* Cramer is dark brown, with a roseate tinge, and the thorax is blackish brown above. The larva feeds on the apple.

Sphinx kalmiæ Smith is hoary and rust-red, and on the hind wings are a median and marginal black band. The caterpillar feeds on the lilac and laurel. It is pale green, with seven oblique, lateral, pale yellow bands, edged above with black, which is again bordered with pale blue. *Sphinx drupiferarum* Smith has the fore-wings blackish brown, with the discal dot and outer edge of the wing whitish fawn-color. The larva feeds on the different species of plum. The body is pale green, with lateral purple bands, edged beneath with white. *Sphinx chersis* Hübner (S. cinerea Harris) is the largest species we have, and is pale ashen, and reddish gray beneath. The larva feeds on the lilac.

The large "potato worm" belongs to the genus *Macrosila*, containing our largest species of the family; the head is proportionally large, and the wings are rather broad, with the interior angles dilated. *M. cingulata* Fabr. has pink hind wings and pink spots on the abdomen. It feeds on the sweet potato. *M. quinque-maculata* Haworth (Fig. 199, moth; *a*,

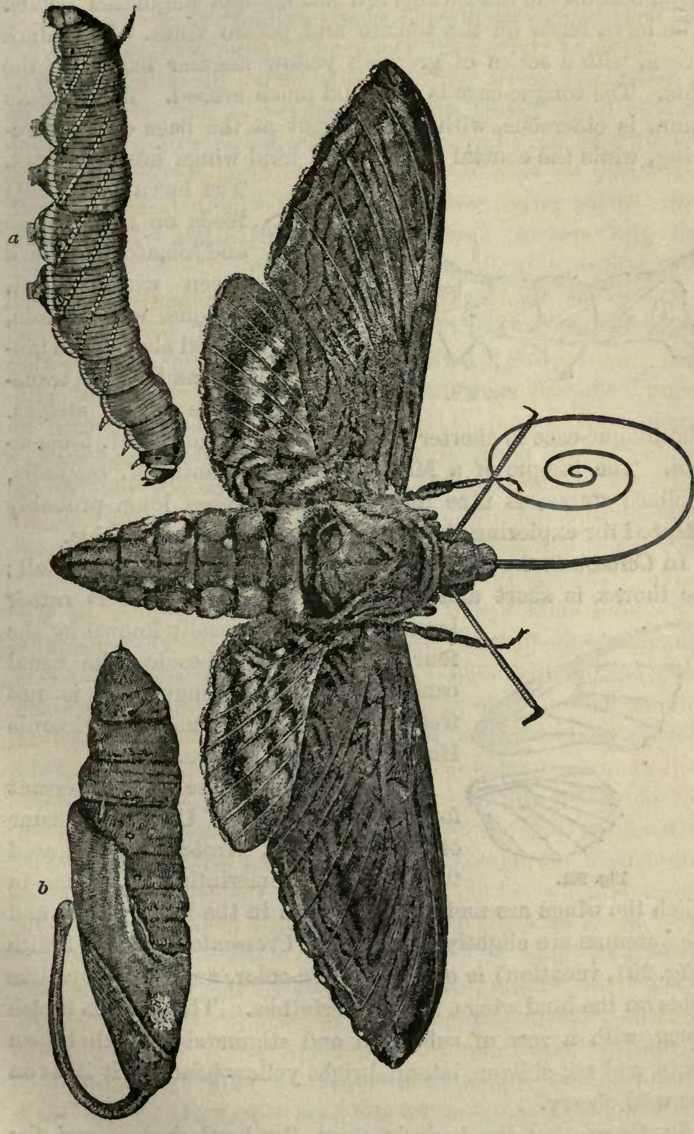


Fig. 199.

larva; *b*, pupa) is gray; the fore-wings are immaculate at the base, and on the hind wings are two distinct angulated bands. The larva feeds on the tomato and potato vines. It is dark green, with a series of greenish yellow angular bands on the side. The tongue-case is long and much arched. *M. Carolina* Linn. is cinereous, with a white spot at the base of the fore-wing, while the central band of the hind wings are indistinct. The larva (Fig. 200) feeds on the tobacco and tomato. It is dark green with lateral, oblique, white bands, edged above with bluish and short transverse black stripes. The tongue-case is shorter and less curved than in M. 5-maculata. The tongue of a Madagascar hawk-moth, *M. cluentius*, Wallace states, is nine and a quarter inches long, probably adapted for exploring the long nectaries of some Orchids.

Fig. 200.

In *Ceratomia* the body is thick, with the head and eyes small; the thorax is short and round, while the abdomen is rather long. The larva is easily known by the four thoracic horns, besides the usual caudal horn. The tongue-case is not free. *C. Amyntor* Hübner (quadricornis Harris) feeds on the elm.

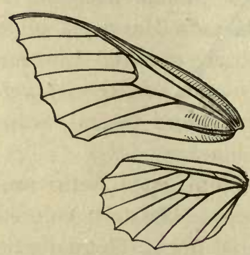


Fig. 201.

We now come to the more aberrant forms of the family. Under the name of *Cressonia* Mr. Grote has separated from the genus Smerinthus, a species in which the wings are more notched than in the latter genus, and the antennæ are slightly pectinated. *Cressonia juglandis* Smith (Fig. 201, venation) is of a pale fawn-color, and has no eye-like spots on the hind wings, as in Smerinthus. The larva is bluish green, with a row of subdorsal and stigmatal reddish brown spots, and six oblique, lateral, bright yellow bands. It lives on the wild cherry.

In *Smerinthus* the body is stout, the head sunken and the maxillæ are only as long as the palpi, being almost obsolete.

The species are said to fly heavily and only in the night. The head of the larva is semi-oval or pyramidal, acute above, and the thoracic rings are obliquely banded on each side. The pupa is smooth, cylindrical and somewhat conical in form. *S. modestus* Harris is a very large species, expanding nearly six inches. It feeds on the Lombardy poplar. *S. excæcatus* Smith has the hind wings rosy on the inner angle. The "ocellus" or eye-like spot is black, with two or three blue pupils. The larva is apple green, with seven oblique, yellowish white lines on the sides, and a bluish caudal horn. It feeds on the apple and the Rosa Carolina. *S. geminatus* Say (Fig. 202, venation of the hind wing) is so-called from the two or three blue pupils in the black ocellus. The hind wings are rosy. The pupa has been found at the roots of willows.


Fig. 202.

In the genus *Philampelus*, or lover of the vine, as its name indicates, the tongue is again as long as the body. The antennæ have a long hook tapering to the end, bearing ciliæ in the male. The abdomen is large and thick, and the wings are deeply concave on the inner border. The larva has a tubercle in place of a caudal horn. The tongue-case of the pupa is not free. *P. vitis* Harris is olive green, with pale green hind wings, which are rose-red towards the inner margin. The larva is flesh-colored mixed with yellow, and with short, transverse, black lines, and lateral, semi-oval, yellowish white bands, edged with black.

In *Deilephila* the abdomen tapers suddenly at the tip and the fusiform antennæ end in a minute hook. The gaily colored larva has a straight and rather short caudal horn. There are no oblique bands on the sides of the body, but a row of subdorsal spots on each side. Clemens states that the anterior segments are much attenuated, and are capable of being withdrawn or shortened, or much extended. "When disturbed they fall from their food-plants, shorten the anterior segments and bend the head inwards." They transform in a cell excavated from the surface. The tongue-case of the pupa is not free. *D. lineata* Fabr. is olive green, with six white lines on the thorax. The hind wings are black with a rose colored central band. The larva is yellowish green; the subdorsal spots consisting of two curved,

short, black lines, with yellow above and beneath. It is double brooded in Texas. The larva feeds on the purslane and turnip, and will, in confinement, eat the apple. *D. chamœnerii* Harris has a white line on each side of the head and thorax. The larva feeds on the willow-herb (Epilobium angustifolium). It is bronze green, dull red beneath, with nine round cream-colored spots, pupilled with black, and a dull red caudal horn.

The genus *Thyreus* has a lateral tuft on each side of the tip of the flattened, oval abdomen, and the head is broad and obtuse, while the fore-wings are excavated just below the tips. The body of the larva tapers gently from the first abdominal ring, and the last segment has a lenticular tubercle instead of a true horn. When at rest it throws its head from side to side thus producing a crepitating noise. It transforms in a cell on the surface. *T. Abbotii* Swainson (Fig. 203 and larva) is dull chocolate brown, with dull sulphureous hind wings, with a dark brown terminal band broken up into short lines on a roseate spot at the inner angle. The larva is reddish brown, with numerous patches of light green. The tubercle is black, encircled at base by a yellowish line and a blackish cordate patch. It feeds on the wild and cultivated grape-vines and on the Ampelopsis quinquefolia, or woodbine.

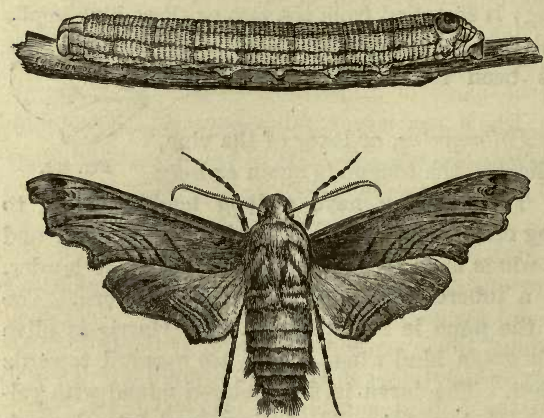


Fig. 203.

The Bee-moth or Clear-wing, *Sesia*, is smaller than the foregoing genera, and the body is flattened, oval and gaily colored with yellow, black and red, while the wings are transparent in the middle. The larva tapers in front, has a dorsal stripe just

above the row of stigmata, and a short recurved horn. It transforms in an imperfect cocoon at the surface of the earth. *Sesia diffinis* Boisd. is pale greenish yellow, with the abdomen black beneath, and the legs black. The larva is pale green, reddish beneath. *Sesia Thysbe* Fabr. is a more common species northward. The thorax is deep olive green, with the abdomen reddish beneath, and with whitish legs. It is abundant, flying in June in the hot sun about the lilac and Rhodora Canadensis.

Fig. 204.

Under the name of *Lepisesia* Mr. Grote has separated *L. flavofasciata* Barnston (Fig. 204, venation of fore-wing) found in Canada, from the genus Macroglossa, represented in Europe by *M. stellatarum* Linn. Mr. Grote also separates from the latter genus, under the name of *Eupyrrhoglossum*, a Cuban moth, which has larger, fuller eyes, and larger hind wings than in Macroglossa. *E. Sagra* (Fig. 205, venation of fore-wing) is a handsome form described by Professor Poey.

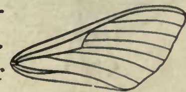


Fig 205.

ÆGERIADÆ Harris. These elegant and gaily colored moths, which by the arrangement of their colors and their clear wings, look like bees and wasps, are readily recognized by their small size, narrow wings, thickened antennæ, and by the tufts at the end of the body, which they can spread out fan-like. They fly very swiftly in the hottest sunshine. The larvæ are borers, living mostly in the hollowed stems of plants. They are whitish, cylindrical, with sparse, short, inconspicuous hairs, and they have no anal horns. They transform in a rude, oblong, oval cocoon, constructed of the chips they make in boring out their tunnels, cemented by a gummy secretion. The pupæ are chestnut-brown, with transverse rows of short teeth on the abdominal rings, by which they make their way out, partly through the hole previously made by the larva for the exit of the moth. The shell of the chrysalis is often left protruding from the hole. This family is, therefore, quite injurious to gardeners.

Ægeria exitiosa Say (Fig. 206, ♂) the Peach-tree borer, has caused the death of many peach trees and also, according to Fitch, occasionally attacks the plum. It is a slender, dark

blue moth, expanding an inch and a half, or more. The male is much smaller than the female (Fig. 207), expanding one inch. She deposits her eggs near the root of the tree. The larvæ are hatched and bore in to feed upon the inner bark and sap wood. When one year old they make their cocoon under the bark or at the root of the tree. Borers of all sizes, Harris states, will be found in the trees throughout the year.

The trees should be protected by wrapping sheathing paper around the bottom of the trunk, and putting fresh mortar around the roots. The wounded part may be covered with clay. *Ægeria pyri* Harris infests the pear tree. It is purple black above and golden yellow beneath, with three yellow bands across the abdomen, the middle band being the larger.

Fig. 206.

The habits of the Grape-root borer, *Æ. polistiformis* Harris, resemble those of the Peach-tree borer. It sometimes destroys grape-vines in the Middle and Western States, but does not attack the Scuppernong variety. The larva lives under ground, the female, according to Walsh, "depositing her egg on the collar of the grape-vine, close to the earth; the young larvæ, as soon as they hatch out, immediately descend into the roots." They attack the sap-wood and bark of the roots, eating irregular furrows. The cocoons are oval, and covered with bits of wood and dirt. They are found, through the summer, in the earth near the roots of the grape, and the moths fly from the middle of June until the middle of September, according to Dr. Kron. Harris describes the moth as being dark brown, tinged with tawny orange on the sides, and banded with bright yellow upon the edge of the second abdominal ring. The thorax and fourth abdominal ring are faintly tinged with yellow, or tawny orange, as are the palpi, under side of the antennæ, and the legs. The female has a little orange colored tuft on each side of the tail, and the males have two tufts on each side. The wings expand from one to one and a half inches. Another species, *Æ. caudata* Harris, inhabits the wild currant.

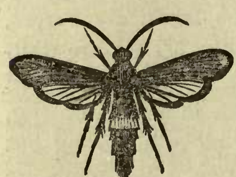


Fig. 207.

The currant borer, *Ægeria tipuliforme* Linn. (Fig. 208; *b*, larva; *a*, pupa, enlarged) has been introduced from Europe, and is a great pest in our gardens, injuring the currant bushes. It is a slender, agile, dark blue moth, found flying in July in the hot sun, about the currant leaves. The larva bores in the stems, and by splitting them open, in the fall and spring, we shall find the larva, which pupates towards the last of May.

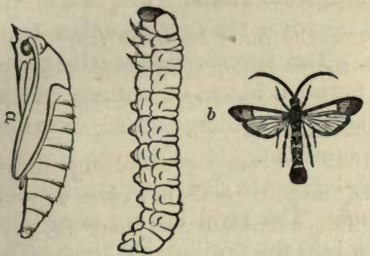


Fig. 208.

Mr. James Ridings describes from Virginia *Æ. quinque caudata* (Fig. 209) which has five filaments at the tip of the abdomen. Its body is blue black, with a transparent spot at the base of the hind wings, while the third abdominal segment is red above.

Fig. 210.

The Squash-vine borer, *Melittia cucurbitæ* Harris (Fig. 210; *a*, larva), often kills, very suddenly, the squash plant. The moth is orange colored, spotted with black, and its hind legs are fringed with long, orange and black hairs. She oviposits on the vine close to the roots, from the tenth of July to the middle of August. The larva eats out the interior of the vine, and usually transforms in a rude earthen cocoon near the roots, but as we have noticed, within the stem, beginning to spin its cocoon the first of October.

Fig. 209.

ZYGÆNIDÆ Latreille. This interesting group connects the diurnal with the nocturnal Lepidoptera. Some of the forms (Castnia) remind us strikingly of the butterflies. The group may be recognized by the rather large free head, and the simple antennæ which are slightly swollen in the middle, or

partially clavate, as in Zygæna. The wings are long and narrow in the typical genera, becoming shorter and broader in the lower genera, such as *Euremia*, from India. The scales are fine, powdery and scattered thinly over the surface, often leaving naked spots on the wings. The species are usually green or deep blue, with scales of purplish black, or entirely black, alternating with gay colors, such as golden, bronze, or white and red. They fly in the hot sunshine.

The sixteen-footed, greenish larvæ are short, cylindrical, the body being obtuse at each end. The head is very small and when at rest is partially drawn into the prothoracic ring. The segments are short and convex, with transverse rows of unequal tubercles which give rise to thin fascicles of very short and evenly cut hairs, which are often nearly absent. The larvæ are either naked, as in Alypia, Eudryas and Castnia, or, as in the lower moth-like species, they are hairy, like those of the Lithosians and Arctians in the next family. Before transforming, the larvæ usually spin a dense, silken cocoon, though Eudryas and Castnia make none at all, and Ctenucha a slight one of hairs. The pupa of Zygæna, especially, is intermediate in form between that of Ægeria and Arctia, being much stouter than the first, and somewhat less so than the last. The head is prominent, and the tips of the abdomen sub-acute. Ctenucha is more like Arctia, while Castnia and Alypia are elongate, slender, with the head made especially prominent by a tubercle on the front of the clypeus.

In common with the *Sphingidæ* and *Ægeriadæ*, the Zygænidæ are confined to the temperate and tropical regions. The family type, *Zygæna*, has its metropolis about the Mediterranean Sea, and thence spreads to the north of Europe, and southward to the Cape of Good Hope. *Zygæna exulans* is found as far north as Lapland, and in vertical distribution rises 6,000 to 7,000 feet in the Alps of Styria.

Castnia is, however, a tropical American genus. Alypia is the most northern genus, extending into the Hudson Bay territories. Glaucopis and allies, which comprise a large number of species, are almost exclusively tropical American. In Australia, as Klug observes, Castnia is represented by Synemon. The American genus Eudryas is represented by very closely allied South African genera.

Castnia closely resembles the Hesperians, though much larger. The species are of large size and of brilliant hues, and fly in the day time, like the butterflies. The head is, however, much narrower in front, and the antennæ inserted higher up. The larva is a borer, living in the stems of Orchids; it is not known, but probably has the usual form of boring caterpillars, and the pupa is said by Klug to resemble that of Cossus.

Alypia comprises black moths, ornamented with white and yellow patches on the wings. The antennæ are long, and a little thickened in the middle. The wings are short and broad. The body of the pupa is not contracted at the base of the abdomen as in Eudryas. The larva feeds on the grape and constructs an earthen cocoon, like that of Ægeria, according to Harris. *A. octo-maculata* Fabr. is black, with eight spots, two on each wing, those on the fore wing being yellowish, those on the hind wing white.

The genus *Psychomorpha* is allied to Alypia, but differs in the broadly pectinated antennæ, and the shorter palpi, which do not pass beyond the front of the head. *P. epimenis* Drury (Fig. 211) is found from Connecticut southwards. It is black, with a broad, yellow, white, irregularly lunate patch crossing the outer third of the wing, and on the under side is larger, being triangular, with two square black spots connected with the costa; on the hind wings is a little larger, mostly regular crescent-shaped brick-red spot; it expands 1.10 inches. Doubleday (Harris Correspondence) states on the authority of Abbot, that the larva feeds on Bignonia radicans, in Georgia. "It is pale, with black lines, and though having the full complement of legs, seems to be a semi-looper in its walk, like Brephos."


Fig. 211.

Eudryas is a peculiar form, gaily colored, and easily known by the densely tufted forelegs, and the short tufts of metallic scales on the thorax and abdomen. The antennæ are filiform, and the abdomen is tipped with hairs. The larva of *E. grata* Fabr. is gaily colored with orange and blue, dotted with black. The body is long and widens towards the eighth ring, which is humped, from which the body rapidly narrows to the tip.

Across each segment is a row of tubercles which give rise to three fascicles of hairs. The pupa is rather long, with a prominent tubercle on the front of the head, and the abdominal tip ends in four tubercles. The larva feeds on the grape during midsummer and at the end of August creeps down, burying itself three or four inches, without making any cocoon. Mr. L. Mitchell of Norwich, Connecticut, has had the kindness to send me "a piece of wood burrowed by the E. grata with one of the pupæ in position." As E. unio is now known to burrow in the stems of plants, our opinion that Eudryas is allied to Castnia would seem to be confirmed by the habits of the larvæ which seem, at least occasionally, to bore into wood.

Eudryas unio Hübner according to Mr. Kirkpatrick, burrows in the stems of Hibiscus, thus resembling Castnia in its habits.

Mr. Grote establishes the genus *Euscirrhopterus* for a moth closely allied to Eudryas. *E. Poeyi* Grote (Fig. 212, fore wing; the venation of the hind wing being "almost identical with that of Eudryas") is a brown and yellow Cuban species.

Fig. 212.

Zygœna is an European genus, and its characters have been indicated in describing those of the family. The antennæ are much thickened towards the end, the wings are long and narrow, and the species are usually entirely blue black, or green with red, or white and red bands and spots.

Acoloithus represents the Procris (P. vitis) of Europe, but the wings are longer and narrower, and the hind wings are very ovate. The gregarious larva of *A. Americana* is little over half an inch long, being short and thick. It is yellow with a transverse row of black spots on each ring. Before pupating it spins a dense cocoon in crevices. The moth is deep blue black, with a saffron collar. Riley states that the "eggs are deposited in clusters, and in twenty-five to thirty days from the time of hatching, the worms, which then measure rather more than half an inch, spin dirty white, flattened cocoons, mostly in clusters on the leaf. Three days afterwards they become chrysalids, also somewhat flattened, and of a shiny yellowish brown; while in ten days more the moths issue."

The genus *Pyromorpha* has thin, oblong wings, very broad at base, the hinder pair being as broad as the fore-pair; with a small, slender body. *P. dimidiata* Herrich-Schæffer (afterwards described by Clemens under the name of Malthaca perlucidula) is blackish brown, with the basal half of the costal region of both wings yellowish. It expands one inch, and is found sparingly in the Middle States, but has been detected near Boston by Mr. Sanborn.

The species of *Glaucopis* and its allies, abounding in tropical America, are represented in the Northern States by *Ctenucha*, which has pectinated antennæ, long, slender, acutely pointed palpi, and rather broad wings; the apex of the fore-pair being much rounded. The thick-bodied larva feeds on sedges and grass, and is very hairy, like an Arctian. The pupa is short and thick, and much like that of Arctia. *Ctenucha Virginica* Charpentier is of a deep indigo blue, with a smoky tinge on the fore wings, a lighter blue abdomen and a saffron collar. It flies in the hottest sunshine. The female lays her smooth, green, spherical eggs in a broad mass.

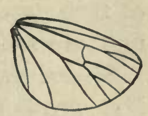


Fig. 213.

Lycomorpha has dentated antennæ, the body is unusually slender, and the wings long and narrow. *L. Pholus* Drury is deep blue, the wings being saffron at base. The larva feeds on lichens. From Mr. E. Bicknell I have received the eggs of this moth. The larvæ hatched August 10th, and closely resembled the larvæ of the Arctians when of the same age.

The genus *Callalucia*, according to Grote, differs from its better known ally, Ctenucha, by its antennæ not being so broadly pectinated, its shorter palpi, and by important differences in the venation of the wings. *C. vermiculata* Grote (Fig. 213, hind wing) occurs in Colorado Territory.

Bombycidæ Latreille. This large and handsome family comprises some of the largest and most regal of moths. Their thick heavy bodies, and small sunken heads, and often obsolete mouth-parts (the maxillæ or tongue being especially short compared with other moths), and the broadly pectinated antennæ, together with their broad, often falcate wings and sluggish habits, notwithstanding numerous exceptions, afford good

characters for distinguishing them. The clypeus is large, the antennæ are inserted higher up than in other moths, so that when in doubt as to the position of some aberrant forms, a reference to these characters enables us to determine quite readily as to their affinities. The larvæ are thick, usually more hairy than other moths, or, as in the typical forms, Attacus, etc., are thick, fleshy and with seven longitudinal rows of long tubercles, crowned with spines. The hairs, especially of the Arctians, are thickly spinulated, so that the cocoons of the hairy species are very dense and made with but little silk, while the naked larvæ, of which the silk-worm is a type, spin very dense cocoons of the finest silk. It is probable that the caterpillars are usually developed in the egg soon after it is laid in autumn. Dr. Burnett has noticed that the embryos of the American Tent caterpillar are developed before winter sets in, and "Guérin-Méneville has found that the larvæ of the Japanese silk-worm (Samia Yama-maï) are developed in the egg within a few days of their deposition in autumn, although they are not hatched until the following spring." (Zoölogical Record, 1864.)

Several moths of this family (Arctia pudica, Setina aurita, Hypoprepia fucosa, etc.) have been known to produce a stridulating noise by rubbing their hind legs over a vesicular expansion situated on the sides of the thorax, and the Death's-head Sphinx has long been known to produce a creaking sound. The pupæ are very short and thick and easily recognized by their plump form. "Bar mentions the occurrence in Cayenne of an aquatic caterpillar, which produces a moth, resembling *Bombyx phœdima* of Cramer. This larva lives at the bottom of the water, and feeds on the roots of an abundant weed." (Bulletin Société Entomologique de France, 1864.)

Lithosia and its allies (Lithosiinæ) have very narrow wings, the antennæ filiform, and the body slender. The larvæ are cylindrical and covered with short, spinulated hairs. Some of them do not spin cocoons, so far as we know, the pupa of Crocota being found under stones with the dried larva skin still adhering to the tip of the abdomen. *Lithosia argillacea* Pack. is slate-colored, with yellow palpi and prothorax. The base of the wings and the tip of the abdomen are yellowish.

Lithosia casta Sanborn (Fig. 214) is an undescribed species

of great beauty, discovered by Mr. Sanborn at Berlin Falls, N. H., August 10th, and also at Ausable Chasm, N. Y. It is pure milk white, with a slight slate-colored tinge on the hind wings, and is slate-colored beneath, especially on the fore wings, and white on the inner edge of the hind wings. Just behind the middle of the white abdomen are tufts of tawny hairs, and the tip is white. It expands one and a quarter inches.


Fig. 214.

Crambidia has still narrower wings. *C. pallida* Pack. is of an uniform drab color and would be easily mistaken for a Crambus. *Nudaria* has broad wings like a geometrid moth, with hyaline spots. The larva is hirsute and makes a thin cocoon of interwoven hairs. *N. mundana* is a European moth. It is represented in this country by *Euphanessa mendica* Walk., which has broader wings and longer palpi. The wings have two rows of smoky transparent spots.

Hypoprepia has rather broader wings than Lithosia. *H. fucosa* Hübner is deep scarlet, with three leaden stripes on the fore wings, the middle stripe situated at the apex of the wing. The larva, Mr. Saunders informs me, is "spiny and black, sprinkled lightly with yellow dots and short lines; there is a dorsal row of yellow dots from the fifth to the twelfth segments. The head is black." Early in May, according to Harris, it makes its cocoon, which is thin and silky, and the moth appears twenty days afterwards.


Fig. 215.

Crocota is red, or yellowish red, throughout, with black margins and dots on the wings. The antennæ are filiform and the wings are broad, being triangular in form. Our most common species is *Crocota ferruginosa* Walk., which is pale rust-red, with two dusky broad bands on the outer half of the wing. A much larger form is *Utetheisa bella* Linn. (Fig. 215), a beautiful moth, whose yellow fore wings are crossed by bands of white, encircling black dots, while its scarlet hind wings are edged irregularly with black.

The genus *Callimorpha* is still larger, with broad wings. *C. Lecontei* Boisduval is white, the fore wings being almost entirely bordered with brown. The caterpillars of this genus are usually dark colored, with longitudinal yellow stripes. By day they hide under leaves or stones and feed by night on various shrubby and herbaceous plants. *C. interrupto-marginata* Beauv. (Fig. 216, fore wing) has an anchor-shaped black spot when the wings are folded, one side of the anchor being seen in the figure.

Arctia and its allies are stout-bodied, with short, moderately broad wings, and simple or feathered antennæ. The hairy larvæ are covered with dense whorls of long, spinulose hairs. They make a loose cocoon of interwoven hairs under the shelter of some board or stone. The pupa is short and thick. *Arctia virgo* Linn. is an exceedingly beautiful insect. Its fore wings sometimes expand two inches and a half, and are flesh-red, streaked thickly with broad, black slashes, and on the vermilion-red hind wings are seven or eight large black spots. The caterpillar is brown. *A. Anna* Grote is allied, but differs in the wholly black abdomen and black hind wings. It was described first from Pennsylvania, and has been detected by Mr. B. P. Mann on the Alpine summit of Mount Washington, N. H.

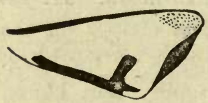


Fig. 216.

The common black and reddish, very hairy caterpillar, found feeding on various garden weeds, is the young of *Pyrrharctia isabella* Smith, a stout-bodied, snuff colored moth. The caterpillar hibernates, as do most of the others of the group of Arctians, and we have kept it fasting for six weeks in the spring, previous to pupating in the middle of June; it remained twenty-seven days in the pupa state, the moth appearing early in June.

Leucarctia differs from Spilosoma in having narrower wings, and the outer edge much more oblique. *Leucarctia acrœa* Smith is white and buff colored. Its caterpillar is the salt-marsh caterpillar, which at times has been very injurious by its great numbers. It is yellow, with long hairs growing from yellow warts, and it makes a coarse, hairy cocoon.

Hyphantria textor Harris is entirely white. The caterpillar, or

"fall web worm," is slender, greenish yellow, dotted with black, with thin, silken hairs. It spins a thin and almost transparent cocoon, or almost none at all. *H. cunea* Drury is white, spotted with black dots. Mr. Saunders informs me that the larva "will feed on Chenopodium album. The head is small, black, shining, bilobate. The body is black, with a slight shade of brown, and sprinkled with very small, whitish dots. Each segment has a transverse row of shining black tubercles, each giving rise to a tuft of hairs of the same color; on each side of the body is a double row of orange-colored spots from the sixth to the twelfth segment inclusive."

The "yellow bear" is the caterpillar of *Spilosoma Virginica* Fabr. The moth is white, with a black discal dot on the fore wings and two black dots on the hind wings, one on the middle and another near the inner angle.

Halesidota has a more slender body, with longer antennæ and palpi, and longer wings than Arctia, being thin and yellowish, crossed by light brownish streaks. The larva is very short and thick, usually white, with dark pencils and tufts of hairs, arising from twelve black tubercles on each ring, placed as seen in the cut (Fig. 217). *H. tessellaris* Smith, the "checkered tussock moth," is ochre-yellow, with its partially transparent fore wings crossed by five rows of dusky spots. *H. caryæ* Harris is light ochreous, with three rows of white semitransparent spots parallel to the very oblique outer margin. "The chrysalis, according to Harris, is short, thick, and rather blunt, but not rounded at the end and not downy." Mr. Saunders writes me, that the larva of *H. maculata* Harris "feeds on the oak. It is 1.30 inches in length; the body is black, thickly covered with tufts of bright yellow and black hairs. From the fourth to the eleventh segments inclusive is a dorsal row of black tufts, the largest of which is on the fourth segments." The moth appears early in June; it is light ochre-yellow, with large, irregular, light, transverse, brown spots on the fore wings.

Fig. 217

These tufted larvæ lead to the tussock caterpillars, which, as in *Orgyia*, have long pencils of hair projecting over the head and tail. The pretty larvæ of this genus are variously tufted

and colored, and feed on the apple tree and various garden vegetables. The males have very broad wings, with very broadly pectinated antennæ, and fly in the hot sunshine in September. The females are wingless and often lay their eggs on the outside of the cocoon, and then die, scarcely moving from their eggs. *O. antiqua* Och. is tawny brown, while *O. leucostigma* Smith is dark brown, with a lunate white spot near the outer angle.

The thick and woolly-bodied, pale yellowish, crinkled-haired *Lagoa* is an interesting genus. The tip of the abdomen is very broad, and the antennæ are curved and broadly pectinated, while the wings are short and broad. The larva is very densely pilose with short, thick, evenly cut hairs, those at the end being longer and more irregular. It is broadly oval, and might easily be mistaken for a hairy Limacodes larva, for, like it, the head is retracted and the legs are so rudimentary as to impart a gliding motion to the caterpillar when it walks. *Lagoa crispata* Pack. is so named from the crinkled woolly hairs on the fore wings. It is dusky orange and slate-colored on the thorax and low down on the sides. Previous to the last moult it is whitish throughout and the hairs are much thinner. The larva (Fig. 218) feeds on the blackberry, and, according to a correspondent in Maryland, it feeds on the apple. The cocoon is long, cylindrical and dense, being formed of the hairs of the larva, closely woven with silk. The pupa is very thin, and after the moth escapes, the thin skin is found sticking partially out of the cocoon, as in Limacodes and its allies (Cochlidiæ).

Fig. 218.

This last group of genera is as interesting as it is anomalous, when we consider the slug-like, footless larvæ, which are either nearly hemispherical, boat-shaped, or oblong, with large fleshy spines, and are painted often with the gayest colors. The pupæ are very thin skinned, and the cocoons are nearly spherical. The moths are often diminutive, the larger forms being stout, woolly-bodied and with short, thick antennæ, pectinated two-thirds their length, while the smaller genera with slender bodies have simple filiform antennæ, and closely resemble some of the Tortrices.

Euclea is a very stout and woolly genus; the antennæ are

three-fourths as long as the fore wings and pectinated on their basal half. The fore wings are a little shorter than the body and the hind wings reach to the tip of the broadly tufted abdomen. *Euclea Monitor* Pack. is cinnamon brown, with a large irregular green patch in the middle of the fore wings. We named this species from the striking resemblance of the larva to the iron-clad "Monitor." It is very regularly elliptical, flattened above, and a broad conspicuous brown spot in the middle of the back reminds one of the "cheese-box" or turret. Long, fleshy, bristling spines arise from each end of the larva.

Empretia stimulea Clemens (Plate 8; Fig. 1; 1 *a*, larva) is our largest species of this group. The moth is rarely found by collectors, and is of a rich, deep velvety brown, with a reddish tinge. There is a dark streak along the basal half of the median vein, on which is situated a golden spot, while there are two twin golden spots near the apex of the wing. It expands an inch and a half. The larva is thick and elliptical, the body being rounded above, but flattened beneath, and a little fuller towards the head. There is a pair of densely spinulated tubercles on each side of the segments, the subdorsal pair on the metathoracic ring, and a pair on the seventh abdominal ring, being two-thirds as long as the body is wide. There are three pairs of small, but well developed thoracic legs, while there are none on the abdominal segments. The body is reddish, with the upper side green between the two largest pair of spines, centred with a broad elliptical reddish spot, edged with white, as is the green portion along the side of the body. According to Mr. S. I. Smith, of New Haven, from whom the specimen figured was received, the larva feeds on the raspberry. He states that the hairs sting, as its specific name indicates. The cocoon is rounded, almost spherical, and is surrounded with a loose web, the whole structure being over three-fourths of an inch in length. The moth appeared June 18th.

Phobetrum has narrow wings, and the male is very unlike the female, which has been raised by Mr. Trouvelot, and was confounded by us with the *Thyridopteryx ephemeræformis* of Haworth. Its antennæ are very broadly pectinated, and the remarkably long, narrow fore wings are partly transparent. *Thyridopteryx nigricans* Pack. must be considered as belonging

to this genus. The cocoon of the latter species is tough, leathery, brown, and nearly spherical. The larva of *P. pithecium* Smith is broad, ovate, flattened, with six long, tongue-like, fleshy lateral appendages. It feeds on the plum, cherry and apple.


Fig. 219.

In *Limacodes* the fore wings are oblong, the costa being straight, while the hind wings scarcely reach to the tip of the abdomen. The fore wings are often crossed by straight lines forming a V. *L. scapha* Harris (Fig. 219) is light cinnamon brown, with a dark tan-colored triangular spot, lined externally with silver, which is continued along the costa to the base of the wing and terminates sharply on the apex. The larva, as its specific name indicates, is boat-shaped, being of the form of a castana nut, and is green, spotted above with brown, and pale beneath, while the sides of the body are raised, the dorsal surface being flattened. It constructs a dense, oval, spherical cocoon, surrounded by an outer thin envelope.


Fig. 220.

Callochlora chloris H-Sch. (Fig. 220) is a pale brown moth, allied to Euclea, and with a broad, pea-green band crossing the fore wings.

Lithacodes (*L. fasciola* Boisd. Fig. 221) and *Tortricodes*, strikingly resemble the genus Tortrix, from their narrow wings, slender bodies, and filiform antennæ.

The subfamily Psychinæ, embraces some remarkably divergent forms. The two genera, *Phryganidia* and *Thyridopteryx*, differing so much in the breadth of their wings and thickness of their bodies, are, however, connected by many intermediate forms occurring in Europe. *Psyche* is a hairy-bodied moth, with broad and thin wings, the female of which is wingless and closely resembles the larva, and inhabits a case, which is constructed of bits of its food-plant. The female of *Psyche helix* has been known to produce young from eggs not fertilized by the male. It lives in a case of grains of sand arranged in the form of a snail shell, thus resembling some Phryganeids in its habits, as it does structurally.


Fig. 221.

The male of *Thyridopteryx* (*T. ephemeræformis* Haworth), the "basket-worm," is stout-bodied, with broadly pectinated antennæ and a long abdomen; the anal forceps and the adjoining parts being capable of unusual extension in order to reach the oviduct of the female, which is wingless, cylindrical, and in its general form closely resembles its larva, and does not leave its case. On being hatched from the eggs, which are, so far as known by us, not extruded from its case by the parent, the young larvæ immediately build little, elongated, basket-like cones, of bits of twigs of the cedar, on which they feed, and may then be seen walking about, tail in the air, this tail or abdomen covered by the incipient case, and presenting a comical sight. The case (Fig. 222) of the full grown larva is elongated, oval, cylindrical, and the fleshy larva transforms within it, while it shelters the female through life. The genus *Œceticus* comprises large species, with much the same habits, growing in tropical America and in Australia.

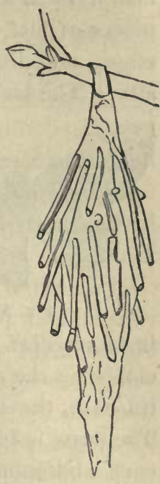


Fig. 222.

A basket-worm, allied to *Œceticus*, has been discovered in Florida, by Mr. Glover, feeding upon the orange, and we give the following account of it from the study of his admirable drawings. With much the same habits, it belongs to quite a different and undescribed genus. The body of the male resembles that of the broad winged Psyche, and indeed, this moth may be regarded as a connecting link between the latter genus and Œceticus. It may be called the *Platœceticus Gloverii* (Fig. 223). Its body is slender, with pectinated antennæ; the wings very broad, irregular, and the hind wings are broad and much rounded, reaching a third of their length beyond the tip of the abdomen. It is dark brown throughout, and expands three-fourths of an inch. The wingless, cylindrical, worm-like female (Fig. 223 *b*) is acutely oval in form, and whitish. The larva (Fig. 223 *c*) is rather flattened and resembles that of

Fig. 223.

Thyridopteryx. It constructs an oval cocoon (Fig. 223 *d*) which hangs to the edge of the leaf.

The genus *Perophora*, another sack-bearer (P. Melsheimerii Harris), is a gigantic Psychid, being about the size of the silkworm moth, which it closely resembles in the imago state. It also lives in a case during the larva state, formed of two oblong pieces of leaf, fastened together in the neatest manner by their edges, and lined with a thick and tough layer of brownish silk. The larva is cylindrical, as thick as a common pipe-stem and light reddish brown in color. The head has extensible, jointed feelers which, when extended, are kept in constant motion, while behind is a pair of antenna-like organs, broad and flattened at the end. The tail is widened and flattened, forming a circular horny plate, which like the operculum of a whelk, closes up the aperture of the case. Before transforming within its case, the larva closes each end with a circular silken lid. The pupa is blunt at the hinder end and with a row of teeth on each abdominal ring. Both sexes are winged. Our species, *P. Melsheimerii* Harris, is reddish ash grey, sprinkled with blackish points, and with a common oblique blackish line.

Fig. 224.

Notodonta and its allies (Ptilodontes Hübner) are mostly naked in the larva state, with large humps on the back, and the hind legs often greatly prolonged, as in Cerura, the "fork-tail." The pupa and moths are best described by stating that they bear a close resemblance to the Noctuids, for which they are often mistaken.

Fig. 225.

Cœlodasys (Notodonta) *unicornis* Smith derives its specific name from the horn on the back of the caterpillar, and its generic name from the large conical tuft of hairs on the under side of the prothorax. The moth is light brown, with irregular green patches on the fore wings. The cocoon is thin and parchment-like, and the caterpillars remain a long time in their cocoons before changing to pupæ. *Nerice bidentata* Walker (Fig. 224) is a closely allied moth. *Edema*

albifrons Smith (Fig. 225) is known by the costa being white on the outer two-thirds. It feeds on the oak, to which it is occasionally destructive. Mr. Riley (American Entomologist, vol. i, p. 39) describes the larva as being of a "bluish white ground-color, marked longitudinally with yellow bands and fine black lines, with the head and a hump on the eleventh segment either of a light coral or dark flesh color." It generally elevates the end of the body. It pupates during the last of September, the moth appearing about the middle of April, in the vicinity of Chicago.

Platypteryx, a small geometra-like moth, with its broad falcate wings, seems a miniature Attacus. Its larva is slender, with fourteen legs, and naked, with several little prominences on the back, and the tail is forked like Cerura. The pupa is enclosed in a cocoon among leaves. *P. geniculata* Walker, and *Dryopteris rosea* Grote, represent this interesting group. We also give a rude sketch, traced from Abbot's drawings, from the advanced sheets of the Harris Correspondence, of an undescribed species of Dryopteris (Fig. 226, and its larva). Doubleday states that the moth is rose-colored, with a few red dots in the yellow portion of the hind wings.

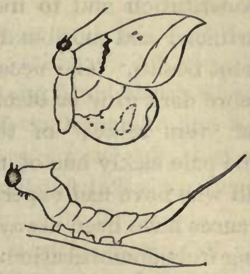


Fig. 226.

The Chinese silk-worm, *Bombyx mori* Linn., has white falcate fore wings, while the hind wings do not reach to the tip of the abdomen, and the antennæ are well pectinated. The larva is naked, rather slender compared with those of the next group, and cylindrical; the second thoracic ring is humped, and there is a long horn on the tail. It is three to three and a half inches long. It is of an ashy or cream color, but "in almost every batch of worms there will be seen after the first moult has occurred, some dark colored, which, at the first glance, appear to be a distinct species," but Captain Hutton, of India, shows that "so far, however, are they from being a mere passing variety that they are actually types of the original species, and merely require to be treated according to the established rules of breeding in order to render them permanent and healthy."

"He attributed the enormous loss of silk-worms by muscardine and other diseases, and the consequent diminution of the crop of silk, to the combined effects of bad and scanty food, want of sufficient light and ventilation, too high a temperature, and constant interbreeding for centuries of a debilitated stock. He asserted that there was no such thing now in existence as a perfectly healthy domesticated stock of silk-worms; and moreover, that it was useless to seek for healthy seed, for whether in Europe, Persia, India or China, the worms were all equally degenerated, or, if there were a difference at all, it was in favor of the European race. He had for several years been experimenting on Bombyx mori, with a view, if possible, to reclaim the worms, to restore to them a healthy constitution and to induce them to *revert* from their present artificial and moribund condition to one of vigor and permanent health. The occasional occurrence in a brood of one or more dark grey or blackish-brindled worms—the 'vers tigrés' or 'vers zébrés' of the French—contrasting strongly with the pale sickly hue of the majority, must have been noticed by all who have had experience in rearing silk-worms; such occurrences have been always spoken of as indicating varieties arising from domestication. The author had endeavored, by a series of experiments, to ascertain the cause of this phenomenon, his conviction being, either that the species had at some time or other been crossed by another of different colors, and that Nature, as sooner or later she always would do, was making an effort to separate them, or that the original color of the worm had been dark, and an effort was being made to *revert* from a sickly condition to the original healthy starting point. He accordingly picked out all the dark colored worms and reared them separately, allowing the moths to couple only *inter se*, and the same with the white worms. In the following spring the one batch of eggs produced nearly all dark brindled worms, whilst the other batch produced white worms, sparingly interspersed with an occasional dark one; these latter were removed into a dark batch, which was also weeded of its pale worms. In the third year the worms were still darker than before, and were always larger and more vigorous than the pale ones, giving larger and better stuffed cocoons. He finally succeeded in

getting an entire brood of dark worms, which he regarded as a sign of increased health and strength in the larvæ, thus proving that the dark worms were of the original race, which also agrees with the colors of the numerous species of the genus of which he has, with others, made known nearly twenty. The author also considers the white cocoons as a strong sign of degeneracy, arguing that the good quality of the silk produced, was no proof of the general health of the insect, as the maladies affected rather the quantity produced, and the present great fineness was due likewise to the disease." (Proceedings of the Entomological Society of London.) The silk-worm is an annual, though some species of this group yield two and three broods in the warmer parts of India. It moults four times, but occasionally only three times.

The cocoon of the silk-worm is white or whitish yellow and is over an inch long and nearly half as broad; 360 cocoons weigh a pound and a half. In France and Italy about thirty-six days elapse between the hatching of the larva and the formation of the cocoon, it taking four days for the spinning of the cocoon. In England and certain parts of India it requires forty-six days for its formation.

The above remarks apply to *Bombyx mori* Linn., the Chinese silk-worm, which feeds on the mulberry, originally derived from the mountainous provinces of China. It is the largest and strongest of the domesticated species. There are, however, as shown by Captain Hutton, twelve species of silk-worms, most of which have been confounded under the name of *B. mori*, and which belong to the genera *Bombyx* of Schrank, *Ocinara* of Walker, and *Trilocha* Moore. There are six domesticated species of Bombyx. There is not silk enough in the cocoon of *Ocinara* to make it worth cultivating (Hutton).

Captain Hutton, speaking of the larvæ of *B. Huttoni*, remarks that it "is curious to observe the instinctive knowledge which these worms appear to possess of the approach of a hail-storm. No sooner are the peals of thunder heard, than the whole brood seems to regard them as a warning trumpet-call, and all are instantly in motion, seeking shelter beneath the thicker branches, and even descending the trunk of the tree to some little distance, but never proceeding so low down as to

lose the protecting shelter of the boughs. For rain they care nothing, but appear to be able to distinguish between the coming of a heavy shower, and the more pitiless pelting of the hail."

Attacus and its allies (Attaci) form the central and most typical group of the family. They are among the largest of insects. The genus *Attacus* is found in China, the East Indies and the South Sea Islands, and in Brazil. Its immense size, falcate wings, with the large triangular transparent spot in the centre, readily distinguish it. *A. Atlas* Linn., from China, expands from seven to nine inches. *Samia* is a smaller genus and with a partially transparent lunate spot in the middle of the wings. *Samia Cynthia* Linn. has been introduced from China and is a hardy worm, quite easily raised, and the silk is

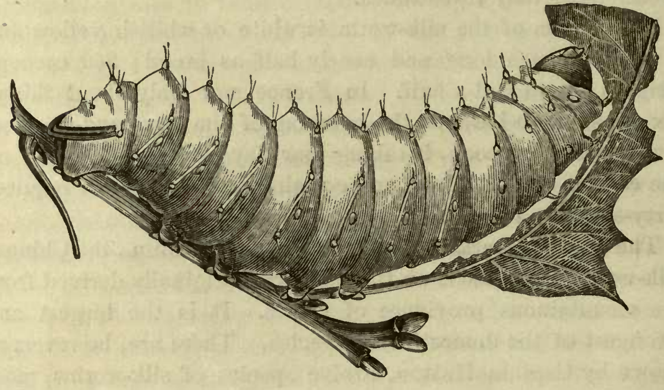


Fig. 227.

of a good quality. Mr. W. V. Andrews urges, in the American Naturalist (vol. ii, p. 311), the cultivation of the Cynthia silkworm in this country, as it is double-brooded, our native species bearing but a single crop of worms. It feeds on the ailanthus, and can be reared in the open air. Among many allied forms, generally referred to the genus Attacus but which still need revision, are the *A. Mylitta* (Tussah worm), from China and India; *A. Pernyi*, from Manchouria, which feeds on the oak, and which has been raised in France, and the Japanese *A. Yama-maï*, all of which produce silk, though less reared in Europe than the Cynthia worm. The silk of the Yama-maï moth approaches nearest that of B. mori, and as it feeds on

the oak, and can be raised in the open air, its cultivation has gained much attention in Europe. *A. Aurota* Beauv. is common in Central and South America. In Brazil it could be raised with success for home use, but is too delicate for a northern climate.

Telea Polyphemus (Pl. 6, male; Pl. 7, female) is brown, with large transparent eye-like spots in the centre of the wings. The thread of which the cocoon is spun is continuous, and is readily unwound. It is coarser than that of the Bombyx mori, but has a rich gloss and can be used very extensively in commerce. Its larva (Fig. 227), which feeds on the oak, is thick, fleshy, striped obliquely with white on the sides, with angulated segments, on which are tubercles giving rise to a few short hairs. The pupa (Fig. 228) is very thick, and the cocoon (Fig. 229) is regularly oval cylindrical.

Fig. 228.

Mr. L. Trouvelot gives an account in the American Naturalist (vol. i) of this silk-worm, which is our most hardy native worm. So successful was he in rearing them that in a single season "not less than a million could be seen feeding in the open air upon bushes covered with a net." The moths leave the cocoons late in May, appearing until the middle of June. They then lay their eggs, generally singly, on the under side of the leaves. In ten or twelve days the caterpillars hatch; the operation usually takes place early in the day. The worm moults five times, the first four moultings occurring at intervals of ten days, while about twenty days elapse between the fourth and fifth moults, this process usually occurring late in the afternoon. It makes its cocoon late in September, and in six or eight days after beginning its cocoon assumes the pupa state, and in this condition passes the winter.

Fig. 229.

The genus *Actias* is at once known by the hind wings be-

ing prolonged into a long tail which reaches far behind the tip of the abdomen. *Actias Luna* Linn. is green and the larva closely resembles that of Telea; it is, however, banded obliquely with yellow instead of white, and spins a cocoon that is of much the same shape. It is not so hardy a worm as the Polyphemus caterpillar. It lives on the walnut, hickory and maple. In the Museum of the Peabody Academy is a closely allied and undescribed species from the west coast of Guatemala, which we would call *Actias Azteca.* It differs from A. Luna in its much smaller size, expanding only three and a half inches, and in the shorter fore wings, the apex being much rounded and with shorter veins, while the "tails" on the hind wings are only half as long as those of A. Luna. It also differs in having the origin of the first subcostal venule much nearer the discal spot than in A. Luna, being very near that of the second subcostal venule. It is whitish green, with markings not essentially differing from those of A. Luna.

Callosamia is a genus with broader wings and no transparent eye-like spots. The larva has large tubercles and is very plump. Its characters are intermediate between those of *Samia* and *Platysamia*. *C. Promethea* Drury is a smaller species than the others. Its larva is pale bluish green, with the head, tail and feet yellow, with eight warts on each ring, those on the two first thoracic rings being the largest, much longer than the rest and coral red. The cocoon is hung by a stout silken cord to the stem of the leaf which is then wrapped around it. It may be found attached to the twigs of the wild cherry, Azalea and Cephalanthus, or button bush, in winter after the leaves have fallen.

Our most common species of this group is the Cecropia moth, belonging to the genus *Platysamia*, which has a broader head and wings than the foregoing genera. The caterpillar of *P. Cecropia* Linn. is longer, with long spinulated tubercles, especially marked on the thoracic rings; the large, very dense cocoon is open at one end and thus the silk cannot be unwound so well as that of the Polyphemus worm, but it is still useful, and *Platysamia Euryale* Boisduval is cultivated in California for its silk, though the cultivation of the Chinese silkworm (B. mori) is carried on there very largely.

The next group, the Ceratocampadæ of Harris, is composed of large moths, in which the hind wings scarcely extend beyond the tip of the abdomen, and the wings are often ocellated. The larvæ are longer than in the *Attaci* and more hairy.

Eucronia Maia Drury has a narrow, lunate, curved white line in the centre of each wing; it expands from two and a half to three inches, and is black with a common, broad, yellowish white band. The caterpillar is elongated, with six long branched prickles on each ring. It feeds on the oak.

Hyperchiria varia Walker (Saturnia Io of Harris) is a little larger than the preceding. The male is yellow and the female reddish brown, with a faint eye-like spot on the fore wing, and on the hind wings a large round blue spot, margined with black and pupilled with white. The caterpillar is green, with spreading tufts of spines, very sharp, stinging severely when the insect is handled, and arising from a tubercle, of which there are six on each ring; the fascicles on the side are as represented in Fig. 230. The pupa is thick, pointed at the tip of the abdomen, and the cocoon is thin, being made under leaves on the ground. It feeds on the corn and cotton, to which it is very harmful southwards, and also on the maple, elm, etc.

Fig. 230.

Citheronia regalis Hübner expands from five to six inches, and its fore wings are olive colored, spotted with yellow and veined with broad red lines, while the hind wings are orange red, spotted with olive, green and yellow. The caterpillar is spiny, having four large acute spinulated spines on the anterior thoracic segments. It feeds on the walnut, hickory and the persimmon tree, and spins no cocoon. A second species, *C. Mexicana* Grote and Robinson, has been described, as its name indicates, from Mexico: it is more orange and less red, with duller yellow patches. Fig. 231 is a rude sketch (from the Harris Correspondence) of the young larva, with two of the peculiar long hairs next the head magnified. A much smaller species, which expands only 3.10 inches, is the *C. sepulcralis* G. and R., which was discovered at Andover, Mass., by Mr. J. O. Treat. It is purplish brown, without any yellow spots, and with a diffuse discal spot, centred

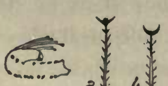


Fig. 231.

with reddish scales. Mr. Treat has raised this fine moth from the larva found on the common pitch pine; it resembles that of C. regalis. It also occurs in Georgia, as it has been figured in the unpublished drawings of Abbot, now in the possession of the Boston Society of Natural History.

Eacles imperialis Hübner has broader wings, expanding from four and a half to over five inches. The wings are yellow with purple brown spots. The larva is but slightly tuberculated, with long, fine hairs. Its chrysalis is like that of Anisota.

The genus *Anisota* is much smaller than the foregoing, with variously striped larvæ, which are naked, with two long, slender spines on the prothoracic ring, and six much shorter spines on each of the succeeding segments. They make no cocoons, but bury themselves several inches deep in the soil just before transforming, and the chrysalids end in a long spine, with the abdominal rings very convex and armed with a row of small spines. The species have much smaller, narrower wings, with less broadly pectinated antennæ than in the foregoing moths. *A. rubicunda* Fabr. is rose colored, with a broad, pale yellow band on the fore wings. *Anisota senatoria* Smith is pale tawny brown, with a large, white, round dot in the centre of each fore wing.

The next group of this extensive family embraces the Lachneides of Hübner, in which the moths have very woolly stout bodies, small wings, with stoutly pectinated antennæ, while the larvæ are long, cylindrical and hairy, scarcely tuberculated, and spin a very dense cocoon. The pupæ are longer than in the two preceding subfamilies. *Gastropacha* (Fig. 159, hind wing) has scalloped wings, and a singular grayish larva whose body is expanded laterally, being rather flattened. *G. Americana* Harris is rusty brown, slightly frosted, and with ashen bands on the wings.

In *Tolype* the wings are entire. *T. Velleda* Stoll is a curious moth, being white, clouded with blue gray, with two broad, dark gray bands on the fore wings. The larva is hairy and is liable to be mistaken for an excrescence on the bark of the apple tree, on which it feeds.

The American Tent Caterpillar is the larva of *Clisiocampa*, well known by its handsome caterpillars, and its large, con-

spicuous webs placed in neglected apple trees and on the wild cherry. The eggs are laid on the twigs, in bunches of from 300 to 400, placed side by side and covered with a tough gummy matter; they are sometimes infested by chalcid parasites.

The larvæ of *C. Americana* Harris hatch out just as the leaves are unfolding and soon form a web, under which the colony lives. They may be destroyed by previously searching for the bunches of eggs on the twigs before the tree is leaved out, and the caterpillars may be killed with a brush or mop dipped into strong soap-suds, or a weak solution of petroleum.

The larvæ become full grown about the middle of June, then spin their dense white cocoons, under the bark of trees, etc., and the moths appear about the first of July. The larva of *C. Americana* is about two inches long, hairy, with a dorsal white stripe, with numerous fine crinkled black lines on a yellow ground, united below into a common black band, with a blue spot on the side of each ring. The moth (Fig. 232, and larva) is reddish brown, with two oblique, dirty white lines on the fore wings. It expands from an inch and a quarter to an inch and a half. The Forest Tent caterpillar, *C. disstria* Hübner (C. sylvatica Harris) differs in the apex of the fore wings being much longer, with two transverse rust brown, nearly straight, parallel lines. It is sometimes destructive to the apple and oak trees.

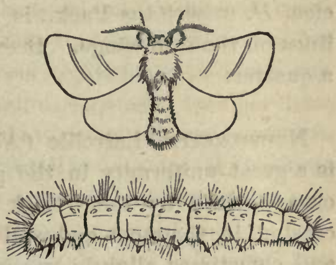


Fig. 232.

The *Hepiali* are a group of boring moths, the larvæ boring in the stems of plants or in trees. The wings are narrow, both pairs being very equal in size, and show a tendency to recur to the net-veined style of venation of the Neuroptera. *Xyleutes* is a large moth, with a stout vein passing through the middle of the discal space, and the short antennæ have two rows of short teeth on the under side. *X. robiniæ* Peck is gray, with irregular black lines and dots on the wings, and a black line on the inside of the shoulder tippets. The hind wings of the male

(X. crepera Harris) are distinctly triangular and yellow on the outer half. The larva is nearly three inches long, is reddish above and covered with sparse long hairs. It bores in various directions through the red oak and locust, and spins a dense cocoon. The pupa is much elongated, with the suture between the segments well marked, and the head and thorax rather small.

Sthenopis is a gigantic moth, with more falcate wings than in Hepialus. *S. argenteomaculata* Harris expands nearly three inches, and is ashy gray, variegated with dusky clouds and bands, with a small, triangular, silvery spot and round dot near the base of the fore wings. Hepialus is smaller, with a larger head and straighter wings. *H. humuli* Linn. is injurious to the hop vine in Europe. Our most common species, *H. mustelinus* Pack., is sable brown, with slight silvery lines on the fore wings. It expands a little over an inch and a quarter.

Noctuælitæ Latreille (*Noctuidæ*). Owlet moths. There is a great uniformity in the genera of this family, which are characterized by their thick bodies, the thorax being often crested, by the stout and well developed palpi, and the simple and sometimes slightly pectinated antennæ. The fore wings are small and narrow, and the rather large hind wings are when at rest folded under them, so that the moth looks much smaller than when flying. They fly swiftly at night, and are attracted by light. The fore wings have almost invariably a dot and reniform spot in the middle of the wing, and the moths are generally dark and dull colored. The larvæ taper towards each end, and are striped and barred in different ways. They have sixteen feet, except those of the lower genera, such as Catocala and other broad-winged genera, which have fourteen, and look when they walk like the Geometers. They make thin earthen cocoons, and the pupæ generally live under ground. In these and other more essential characters, this family is intermediate between the Bombycidæ and the Phalænidæ. There are about 2,500 species known.

These moths can be taken at dusk flying about flowers, while they enter open windows in the evening, and during the night are attracted by the light within. When alighted on the table

under a lamp a slight tap with a ruler will kill them without injuring the specimens. In warm, foggy evenings, they enter in great numbers. The moths fly in July and August, but many species occur only in autumn, while others hibernate and are taken early in the spring. An English writer says, "moths are extremely susceptible of any keenness in the air; a north or east wind is very likely to keep them from venturing abroad. Different species have different hours of flight."

An English entomologist states, that "after dusk the flowers of the willow are the resort of several species of moths (Noctuidæ), some of which have hibernated, and others have just left their pupa state. It is now some fifteen years since the collectors first took moths in this way, that were likely long to have remained deficient in the collections but for the discovery, by Mr. H. Doubleday, of the attractive powers of the sallow blossoms. I believe it was the same gentleman who found out about the same time that a mixture of sugar and beer [or rum and sugar or molasses, etc.], mixed to a consistence somewhat thinner than treacle, is a most attractive bait to all the *Noctuidæ*. The revolution wrought in our collections, and our knowledge of species since its use, is wonderful."

"The mixture is taken to the woods, and put upon the trunks of trees in patches or stripes, just at dusk. Before it is dark some moths arrive, and a succession of comers continue all through the night, until the first dawn of day warns the revellers to depart. The collector goes, soon after dark, with a bull's-eye lantern, a ring net, and a lot of large pill boxes. He turns his light full on the wetted place, at the same time placing his net underneath it, in order to catch any moth that may fall. The sugar bait may be used from March to October with success, not only in woods, but in lanes, gardens, and wherever a tree or post can be found to put it upon. The best nights will be those that are warm, dark and wet; cold, moonlight, or bright, clear and dry nights are always found to be unproductive. It is also of no avail to use sugar in the vicinity of attractive flowers, such as those of the willow, lime or ivy. Sometimes one of the *Geometridæ* or *Tineidæ* comes, and occasionlly a good beetle." The virgins' bower, when in blossom, is a favorite resort of Noctuæ. Many can be taken by

carrying a kerosene lamp into the woods and watching for whatever is attracted by its light.

Thyatira and *Cymatophora* are allied by their small, hairy heads, to the Notodontæ in the preceding family. In Thyratira the palpi are long and depressed, and the fore wings are dark, with five or six large light spots, and the larva is like that of the Notodontæ, the segments being humped, and the anal legs raised while at rest, while *Cymatophora* is pale ashen, the fore wings being crossed by four or five waved lines. The larva is smooth, rather flattened beneath, with a large head. It feeds on trees, between two leaves united by silk. *C. caniplaga* Walker describes from Canada. *Gramatophora trisignata* Doubleday (Fig. 233, fore wing) is a gaily colored species, greenish, marbled with black, with three large, round, brown spots on the fore wings. The larva (Fig. 234) is humped, giving it a zig-zag outline, and is brown with the third to the sixth abdominal rings much paler. It has the unusual power of boring very smooth, cylindrical holes in solid pine wood. We have received specimens of its tunnels from Mrs. J. Brigham. We have found the larvæ just moulting on the leaves of the lilac, September 12th.

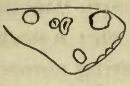


Fig. 233.

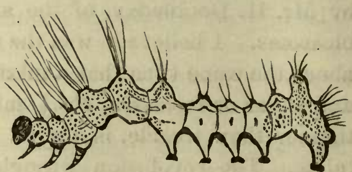


Fig. 234.

In *Acronycta* the head becomes large and broad, the fore wings are broad and short, with dark streaks and a dark mark, like the Greek letter Psi on the inner margin. The larvæ vary in being humped or cylindrical, downy, slightly hairy, or very hairy, and feed exposed on shrubs. The pupa lies in a cocoon made in moss or in crevices of bark. *A. oblinita* Smith (Fig. 235, larva) is whitish gray, with darker streaks on the fore wings.

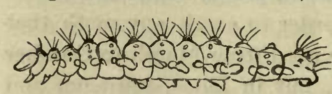


Fig. 235.

Apatela Americana Harris is a large, pale gray moth, without black streaks, whose woolly, yellowish caterpillar, with long, slender pencils of black hairs, feeds on the maple.

We have received from Mr. Sanborn a singular caterpiller allied to this genus (Fig. 236), which is figured in the Harris Correspondence as *Acronycta acris?* var. Americana. "It is greenish brown," according to Harris, "each segment above with a transverse oval greenish yellow spot; the body is beset with a few long black bristles, dilated at the end, which do not grow, as usual, from small warts; there are no long bristles on the second and third thoracic, or on the tenth abdominal rings. It moves very quickly, and rests with the fore part of the body bent sideways. The chrysalis was found under a log fastened to another with a few threads. The moth appeared June 28th."

Fig. 236.

In *Leucania* the fore-wings are short, the outer margin nearly straight, while the hind wings are usually white. *Leucania unipuncta* Haworth (Plate 8, fig. 2; *a*, larva) is the "Army-worm" of the Northern States. Its larva is smooth, cylindrical, tapering rapidly towards each end, and striped with fine, dark, longitudinal lines. It feeds on grasses, and in certain years has greatly ravaged wheat fields. It hides by day among tufts of grass. The moth is rusty, grayish brown, peppered with black scales, and with an oblique row of about ten black dots running towards the apex, and a white discal spot. It expands a little over one and a half inches. It constructs, in the middle of August, a rude earthen cocoon, or cell of dry grass. The moth appears the last of August northwards. Six species of Ichneumon, and one of Tachina, prey upon this species. To prevent the too great accumulation of this very destructive caterpillar, the grass land should be burnt over in autumn. When on the march their armies may be kept out by ditching, and hogs and fowl should be turned into fields during the middle of August, while they are transforming, to prevent their attacks the succeeding year.

Fig. 237.

Agrotis, the Dart-moth, is known by its crested thorax; the palpi are broad and truncated, level with the front, and the antennæ are either somewhat pectinated or distinctly cili-

20

ated. The dot and reniform spot are very distinct, being situated on a black ground, and there is a basal, median, black streak on the fore wing. The apex of the hind wings is much produced. The larvæ, called "cut worms," are thick, with a distinct, horny, prothoracic plate, like that in the Tortrices, or leaf-rollers; they are marked with shining and warty, or smooth and concolorous spots, and often longitudinal dark lines, and live by day hidden under sticks and the roots of low plants; feeding by night. The pupa is found living under ground. *Agrotis tessellata* of Harris (Fig. 237) is dark ash colored; the two ordinary spots on the fore wings are large and pale, and alternate with a triangular and a square, deep, black spot. It expands an inch and a quarter. *Agrotis devastator* Harris is the moth of the cabbage cut-worm. Another very abundant species, often seen flying over the blossoms of the Golden-rod in autumn is the *Agrotis subgothica* (Fig. 238). Mr. Riley states that this moth is the "parent of a cut-worm which very closely resembles that of A. Cochrani, but which has the dark side divided into two stripes. The chrysalis remains somewhat longer in the ground, and the moth makes its appearance from four to six weeks later than A. Cochrani."

Fig. 238.

Fig. 239.

A. suffusa Den. and Schief. (A. telifera of Harris, fig. 239) is so named from the lance-like streaks on the fore wings. It appears late in July, and probably attacks corn, as Mr. Uhler has found the chrysalids at the roots of corn in Maryland. Riley describes the larva under the name of the Large Black Cut-worm. It is an inch and a half in length when crawling.

"Its general color above is dull, dark, leaden brown, with a faint trace of a dirty yellow white line along the back. The subdorsal line is more distinct, and between it and the stigmata are two other indistinct pale lines. There are eight black, shiny, piliferous spots on each segment; two near the subdorsal line, the smaller a little above anteriorly; the larger just below it, and a little back of the middle of the segment, with the line appearing especially light above it. The other two are placed each side of the stigmata, the one anteriorly a little above, the other just behind, in the same line with them, and having a white shade above it."

While cut-worms have usually been supposed to feed upon the roots of grasses and to cut off the leaves of succulent vegetables, Mr. Cochran, of Calumet, Ill., has discovered that one species ascends the apple, pear and grape, eating off the fruit buds, thus doing immense damage to the orchard. Mr. Cochran, in a letter published in the "Prairie Farmer," states that "they destroy low branched fruit trees of all kinds except the peach, feeding on the fruit buds first, the wood buds as a second choice, and preferring them to all things, tender grape buds and shoots (to which they are also partial) not excepted; the miller always preferring to lay her eggs near the hill or mound over the roots of the trees in the orchard, and if, as is many times the case, the trees have a spring dressing of lime or ashes with the view of preventing the operations of the May beetles, this will be selected with unerring instinct by the miller, thus giving her larvæ a fine warm bed to cover themselves with during the day from the observation of their enemies. They will leave potatoes, peas and all other young, green things, for the buds of the apple and the pear. The long, naked, young trees of the orchard are almost exempt from their voracious attacks, but I found them about midnight, of a dark and damp night, well up in the limbs of these. The habit of the dwarf apple and pear tree, however, just suits their nature, and much of the complaint of those people who cannot make these trees thrive on a sandy soil, has its source and foundation here, though apparently, utterly unknown to the orchardist. There is no known remedy; salt has no properties repulsive to them; they burrow in it equally as quick as

in lime or ashes. Tobacco, soap and other diluted washes do not even provoke them; but a tin tube, six inches in length, opened on one side and closed around the base of the tree, fitting close and entering at the lower end an inch into the earth, is what the lawyers would term an effectual estoppel to further proceedings.

"If the dwarf tree branches so low from the ground as not to leave six inches clear of trunk between the limbs and ground, the limbs must be sacrificed to save the tree, as in two nights four or five of these pests will fully and effectually strip a four or five year old dwarf of every fruit and wood bud, and often when the tree is green utterly denude it of its foliage. I look upon them as an enemy to the orchard more fatal than the canker worm when left to themselves, but fortunately for mankind, more surely headed off."

Mr. Riley has named this cut-worm *Agrotis Cochrani* (Fig. 240, and larva) and describes the larva which, according to the observations of J. Townley of Marquette, Wis., also ascends standard trees, not confining its injuries to dwarf trees. The cut-worm is 1.07 inches in length. "It is slightly shagreened and the general color is of a dingy ash gray, with lighter or darker shadings. The back is light, inclining to flesh color with a darker dingy line along the dorsum. The sides, particularly along the subdorsal line, are of a darker shade. On each segment there are eight small, black, shiny, slightly elevated points, having the appearance of black sealing-wax, from each of which originates a small black bristle. The stigmata are of the same black color and one of the black spots is placed quite close to them anteriorly. The head is shiny and of the same dingy color, with two darker marks; thick and almost joining at the upper surface, becoming thinner below and diverging towards the palpi. The upper surface of the first segment is also shiny like the head. The ventral region is of the same dingy color, but lighter, having a greenish tinge

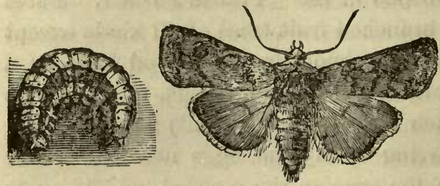


Fig. 240.

anteriorly and inclining to yellow under the anal segment. Prolegs and feet of the same color. It has a few short bristles on the anterior and lateral segments.

"The head is light brown, with a dark brown spot on each side and dark brown above, leaving the inverted Y mark in the middle light brown, and having much the appearance of a goblet, as one looks from tail to head. The cervical shield is dark brown, except a stripe above and on each side. There are sparse, short, white bristles laterally and posteriorly. The venter and legs are of a glaucous glassy color, and the feet are light brown."

"The moth in its general appearance bears a great resemblance to *Hadena chenopodii*, but the two are found to differ essentially when compared. From specimens of H. chenopodii, kindly furnished me by Mr. Walsh, and named by Grote, I am enabled to give the essential differences, which are: 1. In *A. Cochrani*, as already stated, the middle area exceeds somewhat in width either of the other two, while in H. chenopodii it is but half as wide as either; 2. In the Agrotis the space between the spots and between the reniform and transverse posterior is dark, relieving the spots and giving them a light appearance, whilst in the Hadena this space is of the same color as the wing, and the reniform spot is dark. The claviform spot in the Hadena is also quite prominent, and one of its distinctive features; while in the Agrotis it is just about obsolete.

Another larva is called by Mr. Riley the W-marked cutworm. "It measures one and an eighth inches, and its general color is ash gray, inclining on the back and upper sides to dirty yellow: it is finely speckled all over with black and brown spots. Along the back there is a fine line of a lighter color shaded on each side at the ring joints with a darker color. Subdorsal line light sulphur yellow, with a band of dirty brownish yellow underneath. Along the stigmatal region is a wavy line of a dark shade with flesh colored markings underneath it; but the distinguishing feature is a row of black velvety marks along each side of the back, on all but the thoracic segments, and bearing a general resemblance (looking from tail to head), to the letter W. The ventral region

is greenish gray ; prolegs of the same color ; thoracic feet brown black. Head black with white lines in front, resembling an inverted Y, and white at the sides. The thoracic segments frequently have a greenish hue."

Still another, of which the moth is unknown, is described by Mr. Riley under the name of the Pale Cut-worm. "It is of the same length as Cochran's cut-worm, and the general color is pale gray, with a lilac colored hue, caused by innumerable light purplish markings on an almost white ground. There is no particular shading on the back, and it is very slight along the subdorsal line. The stigmatal line, however, being destitute of the above mentioned markings, is almost white. Above this line there is a band of a darker shade than the rest of the body. At first sight this worm appears quite smooth and uniform in color, the most striking feature being the second segment, which is shiny black, with three white lines. One of these lines is on the top, and continues to some extent on the head ; the others are placed on each side of this and do not run down as far. The anal segment has also two black shiny marks on its surface. The stigmata are black and the head is gray, below light shiny, and brown above. Legs and feet of the same color as the under side of the body which is nearly white with a glaucous tinge. There are a few scattering hairs near the tail. This worm is smoother than the others."

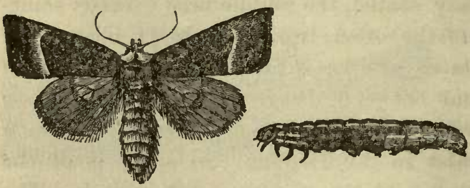


Fig. 241. *a*

In *Gortyna* the antennæ are crenulated in the male, and the fore wings are yellow with darker markings. The larva is dull colored with warty spots. That of *G. flavago*, an European species, feeds in the stems of thistles and the burdock, changing to a pupa inside the stem. *G. leucostigma* attacks the columbine (Harris). The habits of the Dahlia and Aster stalk borer (Gortyna nitela Guenée) have been described by Mr. Riley, who states that the fore wings of the moth (Fig. 241 ; *a*, larva) are lilac gray, speckled with minute yellow dots, with a dis-

tinct white band running across them. The caterpillar is generally of a livid or purplish brown, though varying much as to depth of shading and is darker before than behind. "The young worm hatches about the first of July and immediately commences its work of destruction. It works in such a surreptitious manner as to be too often unnoticed till the vine is destroyed. The plant does not generally show any signs of decay until the cocoon is about fully grown, when it wilts and is past recovery. This occurs about a month after the worm is hatched, and it then crawls just under the surface of the ground, fastens a little earth together around itself by a slight web and changes to a chrysalis of a very light mahogany brown color, and three-fourths of an inch long. The moth comes forth the fore part of September. The careful culturist need fear nothing from this troublesome insect, as an occasional close inspection of the plants about the first of July will reveal the hole where the borer has entered, which is generally quite a distance from the ground, and by splitting downwards one side of the stalk with a penknife it may be found and killed. If this inspection be made at the proper time the worm will be found but a short distance from the hole and the split in the stalk will heal by being kept closed with a piece of thread." (Prairie Farmer.)

Achatodes differs from Gortyna in not having the fore wings falcate. *A. zeæ*, described by Harris, is rust-red with gray clouds and bands on the fore wings and yellowish gray hind wings; it expands an inch and a half. The larva feeds inside the stalks of corn, within which it transforms; it is a little over an inch long, smooth and naked, with the head and the top of the first and last rings of the body black, and with a double row of small, smooth, black dots across each of the other rings. It also infests the dahlia and elder.

The genus *Mamestra* comprises rather large moths in which the antennæ are rather long and simple in the male; the front of the head is smooth and convex, and the reniform dot is very distinct, while the outer margin of the fore wings is rather oblique. The larva is longer than usual and feeds on the leaves of low plants, remaining concealed by day. The pupa is subterranean, the cocoon being made of earth.

Mamestra arctica Boisd. (Hadena amica) is common north-

ward, and is found in the colder subarctic regions of America and Europe. It cuts off the leaves of roses and other shrubs. Fitch states that the larva, late in May in New York, cuts off the young shoots of the currant. It is an inch and a half long, of a shining livid color, with faint dots, from which arise a very short, fine hair. It remains in the pupa state about a month beneath the ground, the moth appearing in July. It is found also in Labrador and in Europe. The moth expands an inch and three quarters and is of a deep Spanish brown, variegated with gray, with a very conspicuous reniform dot; the outer edge is bordered with blue gray. Harris also describes *M. picta*, a reddish brown species, with a conspicuous white Z on the outer edge of the fore wing. The larva is yellow, gaily variegated with three longitudinal stripes. It feeds on garden vegetables, and Mr. Fish informs me that it feeds on the cranberry.

The genus *Plusia* is quite unlike the foregoing genera, as the palpi are long and slender, and the fore wings are acute, with silver marks and lines, usually a dot and dash, like a semicolon; the inner angle is tufted, and the hind wings are triangular.

Our most common species is *Plusia precationis* Guenée, the larva of which, according to Mr. Saunders, feeds on the hollyhock in August. "It is one and a half inches long, the body tapering anteriorly and thickening in the middle and towards the end. The head is small, smooth, shining green, with a black stripe on each side. The body is green with dull whitish, longitudinal lines above and a whitish stripe somewhat more distinct on each side near the spiracles. It changed to a chrysalis August 9th." A species of *Plusia*, like P. præcationis, is figured by Mr. Glover in his unpublished plates of insects injurious to the cotton plant. It has a much curved, semicircular discal spot, with a distinct dot just beyond, the two spots arranged thus . The caterpillar is pale green, the body increasing in size from the head to the tail and with a lateral row of brown dots. "It was found eating the cotton flower in Georgia the last of October." It forms a loose, thin cocoon among the leaves, and the pupa is pale green, spotted above with irregular brown spots. Mr. Glover also figures quite a different species of Plusia, which has the same

habits as the species just mentioned. It belongs, however, to a different section of the genus, and on the discal area is an oblique, golden, irregular oval patch, containing two unequal dots. The larva is pale green and has a broad, lateral, white stripe. The chrysalis is brown and protected by a thin, loose cocoon. *P. divergens* Fabr. lives on the Alps, in Finmark, and in Labrador. Mr. F. G. Sanborn found, July 6th, a closely allied species on the summit of Mount Washington, N. H., which differs from P. divergens in the forked, golden, discal spot being a third smaller, while the two branches of the spot go off at right angles to each other. On the fore wings the second line from the base is acutely dentate on the submedian vein, where in P. divergens it is straight, and the outer line is also dentate, not being so in P. divergens. The hind wings are yellowish at base, with a wide black margin. It may be called *Plusia montana.* Mr. Grote has described *P. ignea* (P. alticola of Walker) from Pike's Peak, which is closely allied to *P. divergens. Plusia œrea* Hübner (Fig. 242, side view) is a reddish brown moth, with obscure markings, and without the usual metallic spots. It expands a little over an inch, and is not uncommon in the Northern States.

Fig. 242.

Anomis is a slender-bodied genus, with triangular fore wings. *A. xylina* Say feeds upon the cotton. It is a brown moth with a dark discal oval spot centred by two pale dots. She deposits, according to Mr. Glover, a low, much flattened, vertically ribbed egg upon the surface of the leaf. The larva is a looper, whence it can be readily distinguished from the army and boll worms, and its body is thickest in the middle, very hairy, green, dotted with black along a subdorsal yellowish line, and with black dots beneath. It matures early in the season, and a second brood becomes fully grown in September and October. When about to transform it gathers a leaf together by a web, thus forming a rude cocoon. (Glover.)

Like our northern army worm (Leucania unipuncta) the Army worm of the South (Fig. 243, and larva, from Glover), makes its appearance in great numbers in a single day, committing the greatest havoc in a few hours. Professor J. Darby, of Auburn, Ala., writes me that "Saturday, Septem-

ber 19th, I was in the field examining the forms (buds before flowering) and the young bolls (fruit after the floral organs have fallen off). I examined all carefully, with no signs of eggs or worms. On Sunday I did not see it. On Monday I passed it as usual and observed nothing unusual. On Tuesday morning I passed it and noticed nothing unusual. On Tuesday noon every plant in the field was stripped of all its upper leaves; not one remaining as far as could be seen, and the plants were covered with millions of worms. I counted on one plant forty-six worms. They commence at the top of the plant, eating every leaf. When the leaves were gone they attacked the young bolls, eating through the perianth and consuming the young cotton. In the course of four days the work was done. They did not touch the grape or any other plant in the field, so far as I have been able to see. Many left the field and thousands were in the road and on the fences, but not one in a thousand thus escaped. To-day, September 23d, there is scarcely one to be seen. Their disappearance is as mysterious as their coming. They have left no signs that I can see, either on the stalks or in the ground. They have extended over hundreds of miles, and nothing has proved a barrier to them, having been as destructive on islands in the river, as elsewhere. One-third of the cotton crop has been destroyed. Nothing of the kind has occurred in thirty years past to my knowledge." The larva is reddish brown, with distinct black spots, the dorsal line being streaked with yellow and black. It hibernates as a moth. The presence of this caterpillar in the West Indies caused the cultivation of cotton to be abandoned. The same, or another species, also appears often in Guiana and other parts of South America. A good remedy against the worm is a mixture of two parts of carbolic acid with 100 of water, to be sprinkled on the leaves of the plant. *Heliothis* has pubescent antennæ, the thorax and abdomen are smooth, and the fore wings slightly acute at tip. The larva is elongated, but not attenuate, with a large head and distinct lines along the body.

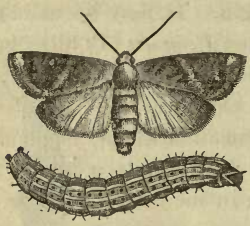


Fig. 243.

It feeds exposed on low plants, preferring the flowers. The pupa is conical and subterranean. *H. armigera* Linn. (Fig. 244; *a*, larva) is the "boll worm" of the Southern States, so destructive to cotton crops. Riley states that it also feeds on the fruit of the tomato, and in Southern Illinois on the silk and green kernels of corn and also the phlox, tomato and corn-stalks, and, according to Mr. T. Glover, it bores into the pumpkin. Mr. Riley, in the "Prairie Farmer," describes apparently the same insect under the name of the "Phlox worm" (Fig. 245, and larva). He states that there are two broods in a year, the first appearing in July, and becoming moths by the middle of August, the second passing the winter in the chrysalis state. The eggs are deposited singly on all portions of the plant, and the caterpillar, when about to become a chrysalis, enters the ground, and interweaves grains of sand with a few silken theads, forming a very slight elastic cocoon." The genus *Heliocheilus* differs from Heliothis in its broader and shorter wings and its venation. *H. paradoxus* Grote (Fig. 246, venation of fore wing) is a pale testaceous moth, with the fore wings darker. It inhabits Colorado Territory.

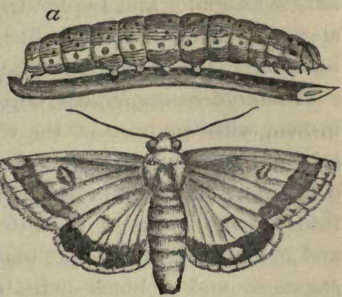


Fig. 244.

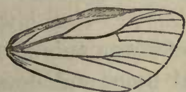


Fig. 246.

Anarta is rather a small moth, with a hairy body and small head; the fore wings are thick and velvety, with confused markings, and the hind wings are yellow or white, often bordered with black. The larva is short and smooth in repose, with the anterior portion of the body bent under the breast. The pupa is enclosed in a

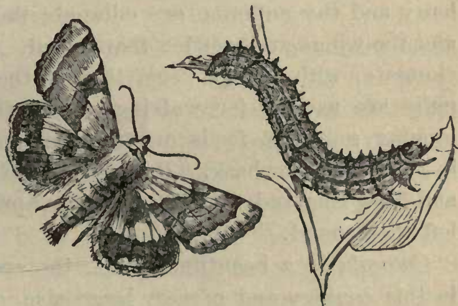


Fig. 245.

cocoon of silk mixed with earth. The genus is arctic or subarctic, and inhabits Alpine summits. *A. algida* Lefebvre inhabits Labrador and Lapland. A closely allied and undescribed species, seems to be peculiar to the summit of Mount Washington, N. H., where it has been detected by Mr. Sanborn.

Xanthoptera semicrocea Guenée (Plate 8, fig. 3; *a*, larva) is brown, with the base of the wings saffron yellow; it expands a little less than one inch. Dr. A. W. Chapman, of Appalachicola, Fla., states in a letter to Mr. Sanborn, that the larva feeds on the leaves of the Pitcher plant, Sarracenia. It is red and cylindrical, with short black tubercles on the top of each segment, and a black cylindrical spine on each side of the four basal rings of the abdomen, surmounted by fine hairs. It does not spin a cocoon but hangs loosely by a few silken threads within the pitcher-like leaf, and the moth is the only insect that can get out of the bristly and narrow opening of the "pitcher."

The little slender-bodied genus *Erastria* has filiform antennæ and a slender crested abdomen, with the usual lines and dots quite distinct. The larva is smooth and slender, with only three pairs of abdominal legs. The pupa is enclosed in a cocoon among leaves or moss. *E. carneola* Guenée is a common species, with the outer edge of the fore wings flesh colored.

In *Brephos* the hind wings are bright orange, the body is hairy and the antennæ are ciliated; the abdomen is slender, and the wings are broader than usual. The larva is smooth, elongate, with sixteen legs, though the first two abdominal pairs are useless for walking, hence the larva has a semi-looping gait. It feeds on trees and makes a slight cocoon in moss or under bark. *B. infans* Moschler inhabits Labrador and New England. It flies early in April before the snow has left the ground.

Catocala is a beautiful genus, the species being numerous in this country and of very large size, often expanding three inches or more; the wings are broad, and in repose form a very flat roof. The larva is elongate, slender, flattened beneath and spotted with black, attenuated at each end, with fleshy filaments on the sides above the legs, while the head is flattened and rather forked above. It feeds on trees and rests

attached to the trunks. The pupa is covered with a bluish efflorescence, enclosed in a slight cocoon of silk, spun amongst leaves or bark. *C. piatrix* Grote is brown on the anterior wings and varied with black, while the hind wings are yellow with a broad median and marginal band. It is common in the Middle and Eastern States.

C. ultronia Hübner (Plate 8, fig. 4; *a*, larva) expands two and a half inches and is of a rich umber color, with a broad ash stripe along the middle of the wings, not extending towards the apex, which is brown. The hind wings are deep red, dusky at base, with a median black band, and beyond is a red band a little broader than the dark one, while a little less than the outer third of the wing is blackish. The larva feeds on the Canada plum. It is gray with black punctures, and the head is edged with black. The segments are transversely wrinkled, and on each one are two whitish and two brownish papillæ; the two brown ones on the eleventh ring are much enlarged, and on the ninth ring is a small brownish horn. On the sides of the body, before the spiracles is a line of light pink filaments fringing the scalloped sides. On July 15th the larva changed to a chrysalis in an earthen cocoon, and the moth appeared on the 2d of August.

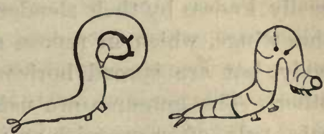


Fig. 247.

Drasteria is a small, grayish moth, with two geminate black dots near the apex, and a broad diffuse line on the fore wing. The larva is a looper, and the body is attenuated at each end. *D. erechtea* Cramer flies very abundantly in grass lands in May and early summer. Mr. Saunders informs me that the larva (Fig. 247) is "one and a quarter inches long and walks like a geometer; the body is thickest in the middle, being somewhat smaller towards the head, but tapering much more posteriorly, while the head is not large and is rather flattened in front and is pale brown, with darker longitudinal lines. The body above is reddish brown, with many longitudinal darker lines and stripes; there is a double whitish dorsal line, with a stripe on each side of the darker shade, another stripe of the same hue on each side close to the stig-

mata, and between these stripes are faint longitudinal lines. It fed on clover and went into the chrysalis state Sept. 21st."

The two remaining genera have broad wings, and are blackish, with numerous transverse waved lines. The edges of the wings are scalloped, the palpi are very long, and the head narrow between the eyes, thus showing their affinities to the *Phalænidæ*. The species of *Homoptera* are of a dark ash color. *H. lunata* Drury has a lunate discal spot.

Erebus is a gigantic moth, with the outer margin very oblique and a large, incised, discal spot and sublunate marginal spots. Our large, blackish species, dark as night, is *Erebus odora* Drury; it expands about five inches. The magnificent, pale gray *Erebus Agrippina* Cramer (E. strix of Fabricius) inhabits Brazil; it expands nearly ten inches.

PHALÆNIDÆ Latreille (*Geometridæ*). The Geometrids are easily known by their slender, finely scaled bodies and broad thin wings, which in repose are not folded roof-like over the body, but are spread horizontally and scarcely overlap each other. The antennæ are usually pectinated. They are delicate, pale, often greenish or yellowish moths, and fly more by day than the Noctuids. The palpi are short and slender, and the tongue, or maxillæ, is weak and short.

The larvæ rarely have more than ten legs, some having fourteen, and a few (Metrocampa and Ellopia) twelve. Thus from the absence of legs on the basal rings of the abdomen, the larvæ are loopers, or geometers, as grasping the object on which they are walking with their fore legs, they bring the hind legs close up to the fore legs, thus making a loop like the Greek letter Omega. They usually let themselves down by spinning a silken thread, hence they are sometimes called "Drop-worms." When about to pupate, the larva either spins a slight, loose, silken cocoon, or conceals itself under a covering of leaves fastened together with silk, or buries itself in the ground without any cocoon, while Harris states that a very few fasten themselves to the stems of plants and are changed to chrysalids, which hang naked and suspended by the tail. The pupa is long, slender, conical, generally smooth, sometimes with lateral protuberances on the head, and usually dark brown, but

often variegated. The species, of which there are about 1,800 described, are widely distributed, and more are found in the arctic regions than of the preceding family.

We place at the head of this family the genus *Urania* and its allies. From their large size, splendid colors, swallow-tailed wings, the fore pair of which are elongated towards the tips, while the outer edge is very oblique, as in Papilio; their habit of flying by day and other resemblances to the butterflies Latreille placed them among the butterflies immediately after the Hesperians. They have also been supposed to belong to the same group as Castnia, but the shape of the head, the long geometriform antennæ, the palpi and the conical pupa and other characters ally them with the Urapteryx and the higher Phalænidæ. *Urania Leilus* is velvet black, the fore wings crossed by emerald green striæ, and the hind edge of the hind wings are banded with light blue and golden, while the fringe and long tail are white. It is found in Surinam and Brazil.

Urapteryx is a true Geometrid, with very square hind wings extending beyond the abdomen, with their outer margin prolonged into a short tail. *U. politia* Cramer is a yellow species found in Mexico and the West Indies. The larva of the European *U. sambucaria* feeds on the oak, elder, bramble, etc., and is elongate, with projections from the eighth and twelfth segments. The pupa is elongate and enclosed in a net-like cocoon suspended by threads.

In *Chœrodes* the hind wings are still angulated, the angle reaching beyond the tips of the abdomen; the falcate apex of the fore wings is acute, and the outer margin is entire and angulated just above the middle. The species are usually pale ochreous, with short transverse strigæ and two darker lines, the outer one of which is obtusely angulated just before the apex. *C. transversata* Drury is a pale ochreous species, which we have found resting on red maple leaves.

The genus *Angerona* comprises the single species *A. crocataria* Fabr., the larva of which (Plate 8, fig. 5 *a*) we have found feeding on the cultivated strawberry during the last of June. It is an inch and a half long and when at rest extends itself straight out. The body gradually increases in size to the first pair of abdominal legs. The head is flattened so as to be

square above, and whitish green, with three longitudinal brown lines. The prothoracic ring is concolorous with the head, from which two brown lines extend, forming an inverted V on the hinder edge. The body is pale grass green above, with the sides bulging. There are four minute black dots on each ring, a whitish, indistinct subdorsal line, and a lateral white line extending to the sides of the anal legs. The body is greenish white. The moth (Plate 8, fig. 5, male) is of a rich yellow, with brown patches on the wings, and appears in July.

In *Endropia*, which is closely allied to Chœrodes, the outer edge of the wings is deeply notched. *E. tigrinaria* Guenée is dirty ochreous, the wings being sprinkled with black; the outer line is nearly straight, ferruginous, paler within, with some submarginal spots, and the basal line on the fore wings is angulated, while the apex is pale and margined externally with blackish.

Metrocampa is pearly white, with the wings a little bent in the middle. *M. perlata* Guen. is pure white, with two darker oblique lines not angulated; it is found not uncommonly northward. The larva of the English *M. margaritata* has twelve legs, and like Catocala has fleshy filaments on the sides just above the legs. The pupa lives on the surface of the earth.

Ellopia has pectinated antennæ and exceedingly thin transparent wings, which are angulated in the middle of the outer edge, and with an inner and outer line, the latter bent nearly at right angles. The larva has twelve legs, but is smooth. The English *E. fasciaria* feeds on firs. *Ellopia flagitiaria* Guenée is pale ashen ochreous, with the speckles and two bands pale brown. It expands from six to eighteen lines.

In *Caberodes* the antennæ are broadly pectinated, and the apex of the fore wings are nearly rectangular. The species are pale ochreous with thick wings, and the outer line terminates near the apex. *C. metrocamparia* Guenée is common northwards; with a blackish discal dot and outer dusky line arcuated and margined with white.

The genus *Nematocampa* is characterized by the four filaments on the back of the larva. *N. filamentaria* Guen. (Plate 8, fig. 7; 7 *a*, larva) is a small moth of a pale ochreous color, with reddish brown lines and dots, a ring in the discal space,

Fig. 1

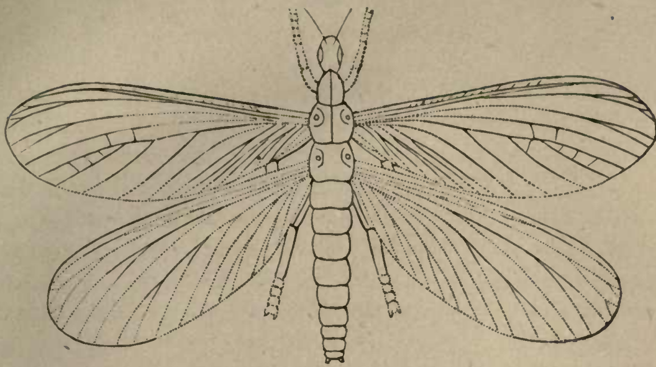


Fig. 2.

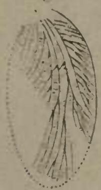


Fig. 3.

Fig. 4.

Fig. 5

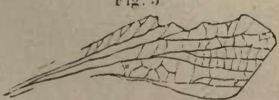


Fig. 6.

Fig. 7.

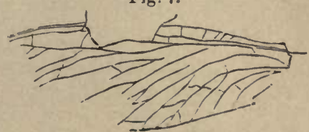


Fig. 8.

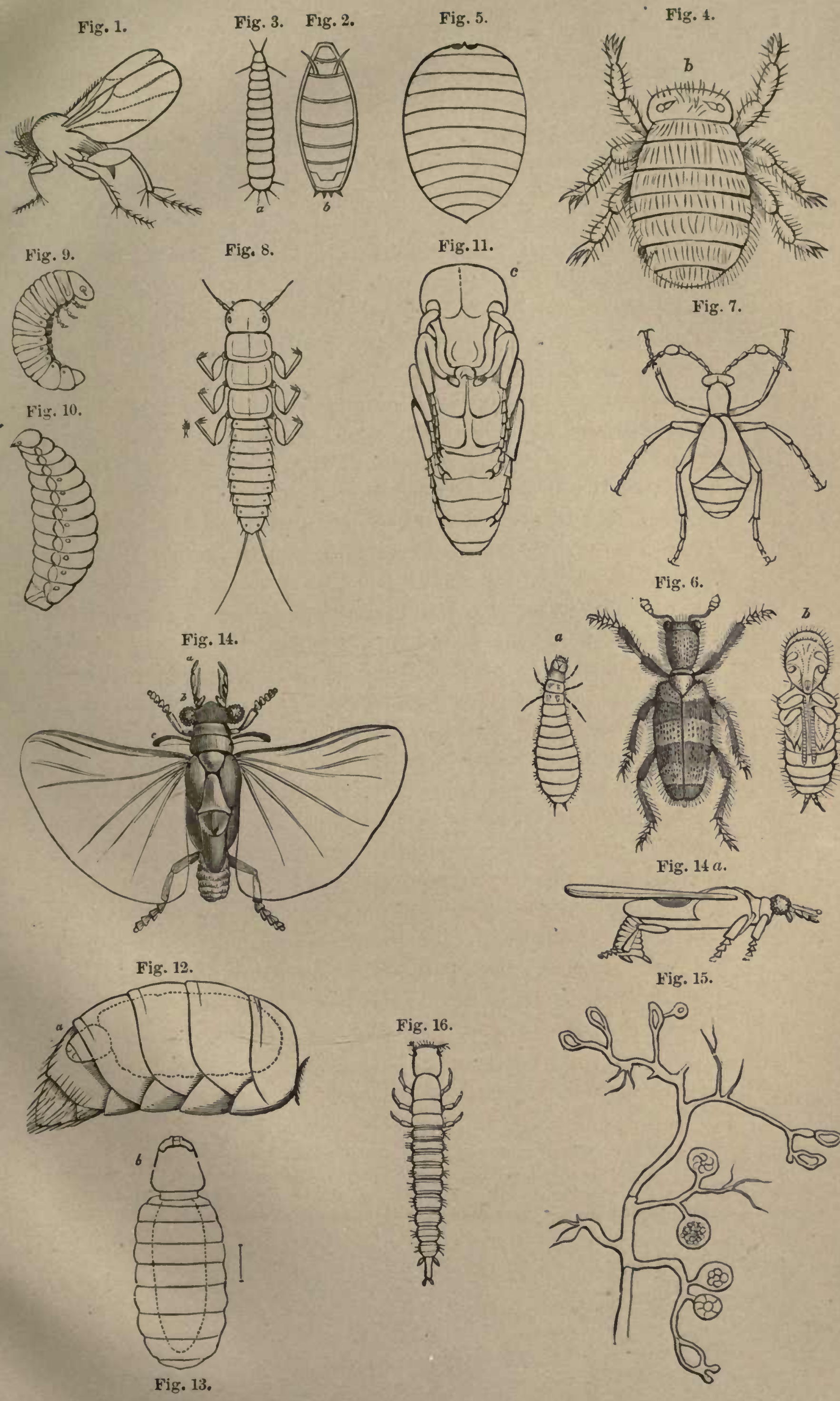


Fig. 1.
Fig. 3.
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Fig. 7.
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Fig. 14.
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Fig. 14 a.
Fig. 12.
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Fig. 15.
Fig. 16.
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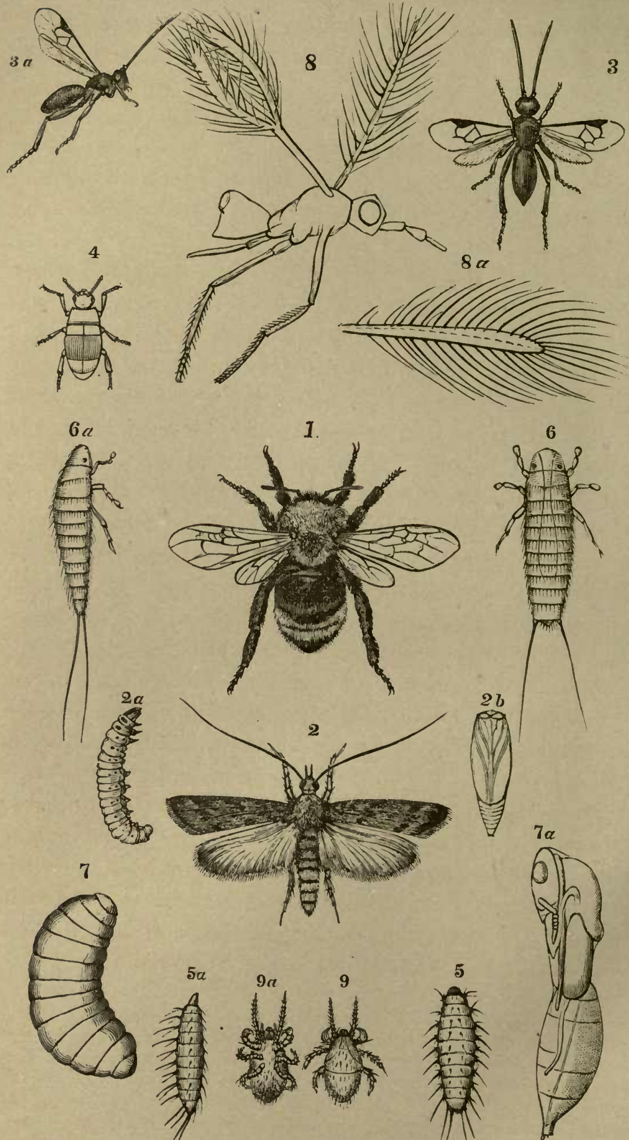
Fig. 13.

Pl. 3.



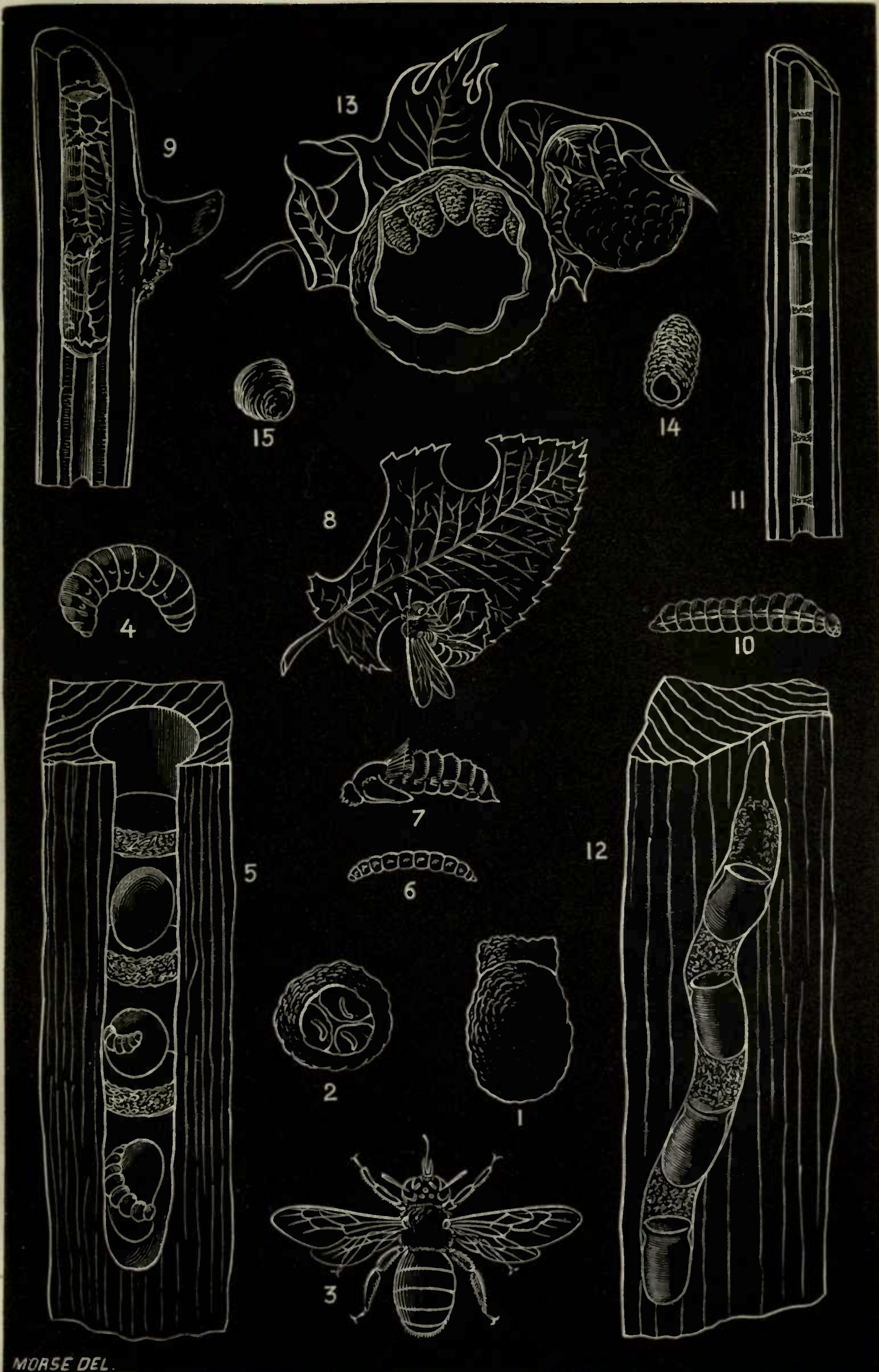

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Plate 6.

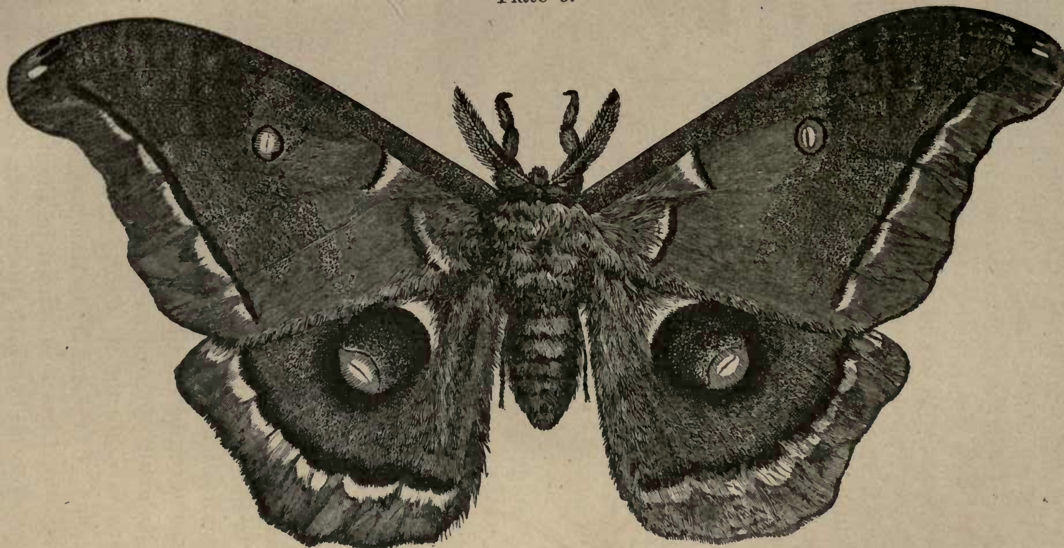

Plate 7.